VOL. XXXV. — No. 7. JULY 1958.

Monthly Bulletin of the International Railway Congress Association

(English Edition)

CONTENTS

OF THE

35th YEAR OF THE ENGLISH EDITION.

No. 12. — DECEMBER 1958.

7 LONDON MAIN LINE TERMINAL STATIONS

are now operating with

WESTINGHOUSE

SIGNALLING EQUIPMENT

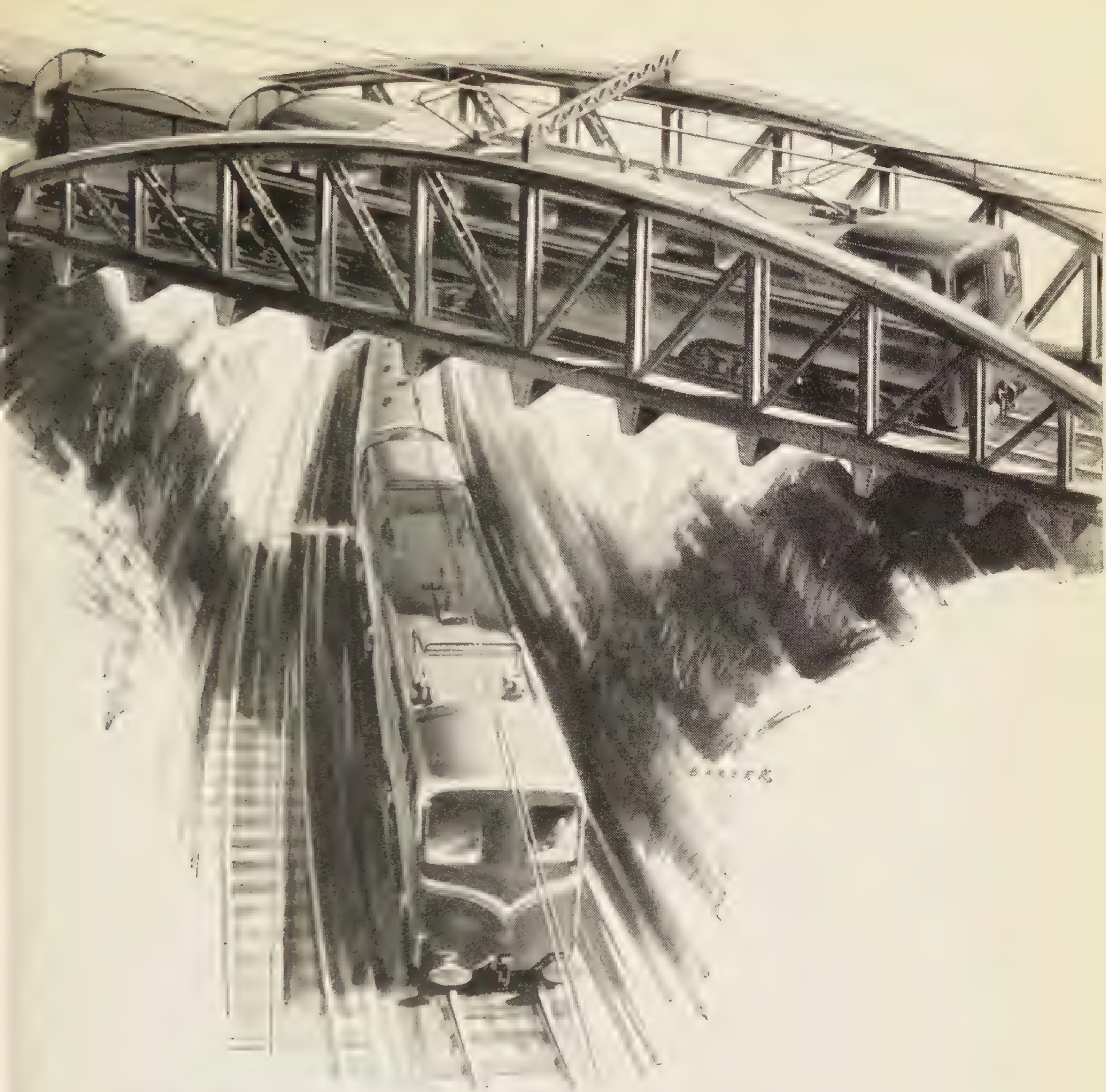
1 Charing Cross, Southern Region. 107-lever power frame.
2 Cannon Street, Southern Region. 143-lever power frame. (Now replaced by a 167-lever frame.)
3 London Bridge, Southern Region. 311-lever power frame.
4 Waterloo, Southern Region. 309-lever power frame.
5 Victoria, Southern Region. 225-lever power frame.
6 Euston, London Midland Region. 227-lever power frame, with electro-pneumatic point operation

and

7 St. Pancras, London Midland Region. 205 routes. O.C.S. route relay interlocking with electro-pneumatic operation of points.

St. Pancras Signal Box • Photographed by courtesy of British Railways, London, Midland Region

Westinghouse Brake and Signal Co. Ltd., 82 York Way, London, N.I.



Alphabetical Index of Advertisers

// MONTHLY BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS ASSOCIATION
(ENGLISH EDITION)

PUBLISHING and EDITORIAL OFFICES : 19, RUE DU BEAU-SITE, BRUSSELS

Price of this single copy : 100 Belgian Francs (not including postage).

Yearly subscription for 1958	Belgium	700 Belgian Francs
	Universal Postal Union	800 Belgian Francs

Subscriptions and orders for single copies to be addressed to the General Secretary, International Railway Congress Association, 19, rue du Beau-Site, Brussels (Belgium).

Advertisements : All communications should be addressed to the Association, 19, rue du Beau-Site, Brussels.

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LIBRARY

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An edition in French is also published.

Vol. XXXV. — No. 7. July 1958.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[621 .335]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

17th. SESSION (MADRID. 1958).

QUESTION 4.

Comparative study of the periodical maintenance and repair of electric locomotives, in particular as regards :

- **the wear of the tyres (influence of the wheel diameter, the axle-load, the speed, the type of bogies and eventually undulatory wear of the rails, etc.);**
- **the maintenance of traction motors and their transmission (flash at the collectors and methods of coping with it, use of roller bearings for the suspension of the motors and the hollow shafts, etc.);**
- **lubricants used (classical and such new types as bisulphide of molybdenum);**
- **wear of the friction strips of the pantographs.**
- **Kind of work and periodicity.**
- **Organisation of the maintenance and influence of common user (banalisation) of the locomotives.**
- **Prime cost in relation to the type of equipment and the age of the engines.**

REPORT

(Austria, Belgium and Colony, Bulgaria, Cambodia, Czechoslovakia, Denmark, Ethiopia, Finland, France and French Union, Western Germany, Greece, Hungary, Indonesia, Italy, Lebanon, Luxemburg, Netherlands, Poland, Portugal and overseas territories, Rumania, Siam, Spain, Switzerland, Syria, Turkey, Union of Soviet Socialist Republics, Viet-Nam and Yugoslavia),

by Mario VIANI,

Sous-Directeur, Chef du Département Electrique, Red Nacional de los Ferrocarriles Españoles (RENFE).

Of the 69 railway Administrations to whom the French questionnaire for question 4 was sent, 16 replied [1]. The others stated either that they had not sufficient experience to give any concrete facts, such as we asked for, owing to the short time their system had been electrified, or else that they had no electrified lines.

May we thank all those Administrations who supplied us with information according to the questionnaire, which has been extremely valuable to us in drawing up this present report.

(1) The data concerning the Polish Peoples Republic were received very late, so that we were not able to include them in the corresponding tables. The main facts have been given in an appendix to the present report.

TAB

No.	Country	Administrations	Systems
1	*WESTERN GERMANY*	*Deutsche Bundesbahn*	single phase 15 000 V 16 2/3 Hz
2	*ALGERIA*	*Algerian Railways*	D.C. 3 000 V
3	*AUSTRIA*	*Austrian Railways*	single phase 15 000 V 16 2/3 Hz
4	*BELGIUM*	*Belgian National Railways* . . .	direct current 3 000 V
5	*BELGIUM (Colony)*	*Lower Congo to Katanga Railways*	single phase 25 000 V 50 Hz
6	*SPAIN*	*R.E.N.F.E.*	single phase 6 000 V 25 Hz D.C. 1 500 and 3 000 V
7	*FRANCE*	*French National Railways*. . . .	D.C. 1 500 V single phase 25 000 V 50 Hz and some lines which 3rd rai to 750 V
8	*HOLLAND*	*Netherlands Railways*.	D.C. 1 500 V
9	*ITALY*	*Italian State Railways*	D.C. 3 000 V others 3 600 V and 16 2/3 Hz
10	*ITALY* .	*North Milan Railway*	D.C. 3 000 V
11	*U.S.S.R.*	*U.S.S.R. Railways*	D.C. 3 000 V
12	*SWITZERLAND*	*C.F.F.*	single phase 15 000 V
13	*SWITZERLAND*	*Rhaetian Railway*	single phase 11 000 V 16 2/3 Hz
14	*TURKEY*	*Turkish State Railways*	single phase 25 000 V 50 Hz
15	*YUGOSLAVIA*	*Yugoslavian Railways*	D.C. 3 000 V single phase 15 000 V

t line	*Electrified lines Mileage*		*Electrified lines*		*Total electrified mileages km*
	Single track	*Double track*	*Main lines*	*Other lines*	
nary	531	1 539	3 925	1 539	5 464
»	307	—	328	51	379
»	577	783	2 979	807	3 786
»	33.3	460.1	958.6	229.6	1 188.2
»	205	—	205	—	205
»	31.313	—	31.313	6.418	37.731
	741.535	340.116	1 421.767	41	1 462.767
»	1 020	3 319	8 387	3 409	11 796
»	189	417	1 158	472	1 630
rd rail	—	98	209	38	247
nary	99	1 235.3	2 569.6	646.2	3 215.8
»	2 872.7	3 315.5	9 503.7	3 821.1	13 324.8
»	121.16	82.74	286.64	152.36	439.00
»	—	—	6 300.—	—	6 300.—
»	1 622.—	1 240.—	4 102.—	1 830.—	5 932.—
»	277.—	—	277.—	71.—	348.—
»	—	28.—	56	—	56
»	103	61	225	74	299

I.

I. GENERAL INFORMATION.

Table I gives data concerning the electrified system of each of the 15 Administrations shown in columns 2 and 3, giving the type of electrification, the type of current, the length of the electrified lines, either their length or the length of lines, and the total number of km electrified.

Lower Congo :

Increase of 137 km of lines, to be extended by the electrification of another 184 km;

Spanish National Railways (Spain) :

Increase of 613 km of single track;

French National Railways (France) :

Increase of 1 955 km in electrified lines;

TABLE 2.

No.	*Country*	*Administrations*	*Gross T-km electric traction*	*Gross T-km steam traction*
2	*ALGERIA*	*Algerian Railways*	100 % electric	—
3	*AUSTRIA*	*Austrian Railways*	13 274 000	10 101 000 000
4	*BELGIUM*	*Belgian National Railways*	4 782 492 000	20 587 446 000
5	*BELGIUM (Colony)*	*Lower Congo to Katanga Railway*	674 671 000	2 576 184 000
6	*SPAIN*	*R.E.N.F.E.*	4 656 625 800	29 112 112 110
8	*HOLLAND*	*Netherlands Railways*	16 474 000 000	4 220 000 000
9	*ITALY*	*Italian State Railways*	$\frac{\text{electric t.}}{\text{steam t.}} = 2$	—

The Rhaetian Ry. (Switzerland) is the only Administration to look upon its situation in December 1955 as final. All the others informed us that the situation at that date had evolved as follows :

Deutsche Bundesbahn (Germany) :

Electrified lines increased by 131 km;

Austrian Railways (Austria) :

Catenary extended over 441 km;

Belgian National Railways (Belgium) :

Electrification increased by 92 km of double track;

Netherlands Railways (Holland) :

Increase of 284 km;

Italian State Railways and North-Milan (Italy) :

Increase of 276 km on the Italian State Rys. and 14 km on the North-Milan Co.;

U.S.S.R. Railways (Russia) :

Increase of 1 019 km;

Jugoslavian Railways (Jugoslavia) :

Electrification increased by 30 %.

TABLE 3. — **General data concerning the various types of locomotives.**

Ref. No.	Country	Administrations	Type or series	Number of locomotives	Average annual mileage	Year of construction	Builder		Length over buffers	Distance between outer axles	Axle arrangement	Distance between outer axles of bogie	Distance between bogie pivots	Weight in running order		Weight per driving axle	Weight per carrying axle
					km		Mechanical part	Electrical part	m	m		m	m	Mechanical part	Electrical part (transmission included)	t	t
1	WESTERN GERMANY	Deutsche Bundesbahn	E 04	6	155 000	1 934	A E G	A E G	15.120	11.600	1' Co 1'	2.800	9.300	92.0 (total weight)		20.5	15.3
			E 16	19	141 000	1 926	Krauss	B B C	16.300	12.600	1' Do 1'	2.700	9.840	110.8 »		20.1	15.3
			E 18	41	231 000	1 935-40-55	A E G	A E G	16.920	12.800	1' Do 1'	2.800	10.500	108.5 »		19.5	15.2
			E 44	123	114 000	1 931-55	Henschel-Krauss	S S W	15.290	9.800	B'o B'o	3.500	6.300	78.0 »		19.5	—
			E 94	112	138 000	1 940-56	A E G-Krauss	A E G-S S W	18.600	13.500	C'o C'o	4.600	10.000	118.5 »		19.7	—
2	ALGERIA	Algerian Railways	CC - 6 AE	29	79 894	1 930	Schneider	C E F	16.400	12.800	Co-Co	4.350	9.024	115.0 (total weight)		19	—
			BB - 4 AE	2	58 974	1 939	Jeumont	Jeumont	13.500	9.500	Bo-Bo	3.000	6.500	76.0 »		19	—
3	AUSTRIA	Austrian Railways	1 010	16	230 000	1 935	S G P	ABES	17.860	12.550	C'o C'o	4.100	8.600	57.5	50.5	18.3	—
			1 110	2	—	1 956	»	»	17.860	12.550	C'o C'o	—	8.600	57.5	50.5	18.3	—
			1 018	8	211 500	1 939	Lofag	A E G U, S S W	16.920	12.800	1' Do 1'	4.900	10.500	64	46	19.7	15.6
			1 118	1	—	1 934	A E G	A E G	16.920	12.800	1' Do 1'	—	10.500	64	44.5	19.6	—
			1 020	47	139 000	1 940	Lofag, Krauss, A E G	A E G U, A E G-S S W	18.600	13.700	C'o C'o	4.600	10.000	71.5	47	20	—
			1 040	16	167 000	1 950	Lofag	A B E S	12.920	9.040	B'o B'o	3.100	5.940	41.25	49	20.25	—
			1 041	25	151 000	1 952	S G P	»	15.320	10.700	B'o B'o	3.200	7.500	44	39	20.75	—
			1 141	19	162 000	1 955	»	»	14.260	10.700	B'o B'o	3.200	7.500	42.8	37.2	20	—
			1 045	12	95 400	1 927	Lokfabr. Wr. Neust. Lofag	Elin	10.300	7.100	B'o B'o	2.300	4.800	27.3	33.9	15.3	—
			1 145	13	77 200	1 930	Krauss & Co., Lofag	»	11.880	8.450	B'o B'o	2.950	5.500	40.4	30.2	17.65	—
			1 245	38	119 400	1 934-38	Lofag	A B E S	12.920	9.040	B'o B'o	3.100	5.940	50	33 et 31.7	20.8 and 20.5	—
			1 061	5	43 200	1 926	»	A E G U	9.990	5.000	D	5.000	3.700	30	24.8	13.7	—
			1 161	21	46 500	1 928	»	»	10.500	5.000	D	5.000	3.700	33	23	14	—
			1 062	12	53 100	1 955	»	A E G U-S S W	10.820	5.100	D	5.100	3.750	44.5	23.6	17	—
			1 570	4	89 000	1 926	Krauss & Co.	S S W	14.000	11.000	(1 A) Bo (A 1)	3.850	8.800	54.8	39.2	16.5	14
			1 670	26	120 000	1 928	Krauss & Co., Lofag	»	14.460	11.000	(1 A) Bo (A 1)	3.950	8.800	61	46	18.5	17
			1 670.100	4	120 000	1 932	Lofag	»	14.684	11.200	(1 A) Bo (A 1)	4.050	8.980	66	46	19	18
			1 072	6	45 500	1 913	S G P	A E G U	10.526	5.900	1' B 1'	2.400	4.000	29.8	26.2	14	14
			1 073	11	93 500	1 923	Steg	»	12.810	9.890	1' C 1'	5.670	5.670	41.2	32.3	15	13.2
			1 080	16	46 000	1 923	Krauss & Co.	S S W	12.850	7.750	E	7.750	4.750	40.6	36.4	15.4	—
			1 180	10	51 600	1 926	»	»	12.750	7.750	E	7.750	4.750	42.7	37.8	16.3	—
			1 280	20	47 300	1 927	Steg u. Lofag	A E G	12.100	6.550	E	6.550	3.850	45.7	36.3	16.4	—
			1 089	6	67 700	1 923	Lofag	O B B W	20.350	17.700	(1'C) (C 1')	5.520	5.520	68.1	46.5	14.8	13.8
			1 189	9	89 700	1 926	»	»	20.350	17.700	(1'C) (C 1')	5.520	5.520	69.3	46.7	15.2	14.2
			1 099	16	44 300	1 911	Krauss & Co.	S S W	10.900	7.900	C' C'	2.400	6.100	24.4	25.4	8.3	—
			4 030	1	—	1 956	S G P	A E G U, N B B C, Elin	23.190	19.050	B'o B'o	—	16.250	34.5	21	13.89	—
			4 041	8	82 500	1 926	Krauss & Co.	Elin	20.520	16.430	2' B'o	3.100	13.330	50.5	22.2	18.2	—
			4 042	2	50 500	1 936	S G P	A E G U, S S W	23.520	19.160	B'o 2'	3.200	15.960	29.3	14.5	12	—
			4 060	2	83 000	1 936	Lofag	S S W, N B B C, Elin	15.524	10.800	B'o B'o	3.100	7.700	36	24	15	—
			4 061	1	—	1 956	»	A B E S	16.330	11.300	B'o B'o	3.200	8.100	37	28	16.25	—
4	BELGIUM	Belgian National Railways	101	20	81 650	1 949	Baume et Marpent	A C E C-S E M	12.890	8.950	Bo Bo	2.950	6.000	44.8	36.7	20.375	—
			120	3	106 000	1 950	»	»	17.180	12.000	Bo Bo	3.500	8.500	43.75	37.25	20.25	—
			121	3	82 700	1 950	F.U.F. de Haine-St. P.	B B C	16.300	11.600	Bo Bo	3.600	8.000	41.1	39.9	20.25	—
			122	50	106 000	1 954	La Brugeoise et Nivelles	A C E C-S E M	18.000	12.050	Bo Bo	3.450	8.600	44.02	37.48	20.375	—
			123	—	—	1 955-56	»	»	18.000	12.050	Bo Bo	3.450	8.600	52.72	40.58	20.825	—
5	BELGIUM (Colony)	Lower Congo to Katanga Railway	2 100	12	140 430	1 951-52	La Brugeoise et Nivelles	A C E C	15.065	9.700	Bo Bo	2.500	7.200	38.1	36.4	18.625	—
			2 200	10	—	1 955-56	»	»	15.670	10.450	Bo Bo	3.450	7.000	36.92	38.9	18.955	—

TABLE 3. — **General data concerning the various types of locomotives** *(continued)*.

Ref. No.	Country	Administrations	Type or series	Nominal service voltage	Characteristics of the traction motor								Transmission	Traction motor suspension
					Continuous rating				Hourly rating					
					Voltage	Amperage strength	Speed	Speed (tyres half-worn)	Voltage	Amperage strength	Speed	Speed (tyres half-worn)		
				kV	V	A	t/m	km/h	V	A	t/m	km/h		
1	WESTERN GERMANY	Deutsche Bundesbahn	E 04	15	534	1 585	1 025	102	534	1 765	980	98	Elastic (with springs)	Frame
			E 16	15	650	690	825	94	650	1 020	770	88	Buchli	»
			E 18	15	594	1 520	1 160	122	594	1 650	1 110	117	Elastic (with springs)	»
			E 44	15	638	1 090	1 750	86	638	1 175	1 545	76	Nose-suspended	Nose-suspended
			E 94	15	536.5	1 280	1 235	71	536.5	1 430	1 184	68	»	»
2	ALGERIA	Algerian Railways	CC - 6 AE	3	1 350	208	585	32.8	1 350	245	555	31.1	2 gear trains, crown wheel on axle and pinion on the motor	Nose-suspended
			BB - 4 AE	3	1 350	247	575	44.48	1 350	265	560	43.3	2 gear trains, elastic crown wheel on axle and pinion on the motor	»
3	AUSTRIA	Austrian Railways	1 010	15	517	1 375	1 320	99	517	1 600	1 200	90	B B C with springs	Gearing with dampers
			1 110	15	517	1 375	1 320	85	517	1 600	1 200	77	» »	» » »
			1 018	15	562.5	1 560	1 050	105	562.5	1 800	975	97.5	A E G Kleinow cage with springs	With springs
			1 118	—	594	1 520	1 160	122	594	1 650	1 112	117	» » » » »	» »
			1 020	15	536.5	1 220	1 230	71	536.5	1 280	1 180	68	Claws	—
			1 040	15	514.5	1 250	1 270	71	514.5	1 450	1 180	65.5	SECHERON	SECHERON
			1 041	15	514.5	1 250	1 270	71	514.5	1 450	1 180	65.5	A E G Kleinow cage with springs	With springs
			1 141	15	540	1 250	1 360	85	540	1 450	1 230	77	S S W - ring springs	Rubber buffers
			1 045	15	340	960	1 185	48	340	1 180	990	40	SECHERON	SECHERON
			1 145	15	340	1 100	1 185	48	340	1 300	1 095	44.2	»	»
			1 245	15	391.5 and 415	1 150 and 1 190	950 and 1 040	53 and 58	391.5 & 415	1 400 & 1 450	840 & 1 005	47 & 56	»	»
			1 061	15	392	1 600	835	37	392	2 000	725	32	Winterthur oblique rods	Pinions with dampers
			1 161	15	441	1 840	815	36	441	2 360	705	31	» » »	» » »
			1 062	15	518	1 850	1 000	49	518	3 140	360	18	» » »	» » »
			1 570	15	450	960	1 180	76	450	1 260	1 020	66	S S W - Vertical	Suspension of rotor
			1 670	15	475	720	1 170	75	475	800	1 080	69	» »	Torsion shaft
			1 670.100	15	475	720	1 170	75	475	800	1 080	69	» »	» »
			1 072	15	546	1 350	310	58	546	2 500	208	39	Cranks parallel with hollow axle and oblique rods.	—
			1 073	15	542	1 090	935	74	542	1 340	795	63	Sets with reducer	Pinions with dampers
			1 080	15	494	850	1 170	47	494	1 100	945	38	Claws	—
			1 180	15	500	980	1 020	41	500	1 260	892	36	»	—
			1 280	15	474.5	1 870	745	42.6	474.5	2 400	665	38	Kando with articulated frame	Pinions with dampers
			1 089	15	664.5	850	760	57	664.5	1 000	706	53	Sets with reducer	—
			1 189	15	484	1 250	760	60	484	1 400	700	55	» » »	—
			1 099	6	316	1 250	800	35	316	1 350	640	28	» » »	—
			4 030	15	497	1 090	1 430	73	497	1 250	1 300	66.4	Disc	Torsion shaft
			4 041	15	316	950	990	62	316	1 250	845	53	Claws	Gearing with dampers
			4 042	15	372	700	1 270	67	372	850	1 135	70	»	—
			4 060	15	401	700	1 630	79	401	850	1 460	69	»	—
			4 061	15	448	1 090	1 108	94.5	448	1 250	1 025	87.5	Discs	Torsion shaft
4	BELGIUM	Belgian National Railways	101	3	1 500	239	617	43.2	1 500	293	560	39.4	Bilateral with elastic gearing	Nose-suspended
			120	3	1 500	292	710	50	1 500	355	625	40	Unilateral with main gearing	»
			121	3	1 500	320	440	50.7	1 500	384	415	46.4	B B C discs	Elastic
			122	3	1 500	310	685	50.7	1 500	336	665	49.2	Unilateral with elastic gearing	Nose-suspended
			123	3	1 500	310	685	50.7	1 500	336	665	49.2	» » » »	»
5	BELGIUM (colony)	Lower Congo to Katanga Railway	2 100	22	480	850	1 580	47.5	—	—	—	—	Hollow axle and SECHERON springs	Entirely suspended
			2 200	22	235	2 420	890	45.5	—	—	—	—	Elastic gears	Nose-suspended

TABLE 3. — **General data concerning the various types of locomotives** *(continued)*.

Ref. No.	*Country*	*Administrations*	*Type or series*	*Gear ratio*	*Diameter of the driving wheels mm*		*Maximum speed authorised*	*Brief description of possible coupling between bogies*	*Remarks*
					new	*worn*	*km/h*		
1	*WESTERN GERMANY*	*Deutsche Bundesbahn*	E 04 E 16 E 18 E 44 E 94	33/97 51/134 34/95 18/83 20/79	1 600 1 640 1 600 1 250 1 250	1 510 1 550 1 510 1 160 1 160	130 120 150 90 90	Series E 44 : Simple central coupling for traction. Series E 94 : Coupling bar for traction or compensation coupling for stabilisation.	
2	*ALGERIA*	*Algerian Railways*	CC - 6 AE BB - 4 AE	4.38 3.04	1 360 1 300	1 285 1 200	75 175	Series CC-6 AE : Coupling screw through a double ball joint, male and female, without lateral displacement but with free vertical play ensuring the independence of the bogies. Series BB-4 AE : Axial coupling screw joining two swing bolsters supported on two helical springs. Convex and concave lateral buffers on each pair.	
3	*AUSTRIA*	*Austrian Railways*	1 010 1 110 1 018 1 118 1 020 1 040 1 041 1 141 1 045 1 145 1 245 1 061 1 161 1 062 1 570 1 670 1 670.100 1 072 1 073 1 080 1 180 1 280 1 089 1 189 1 099 4 030 4 041 4 042 4 060 4 061	1/3.18 1/3.7 1/2.939 1/2.79 1/3.95 1/4.43 1/4.43 1/3.83 1/5.867 1/5.867 1/4.43 1/4.696 1/4.696 1/4.125 1/3.824 1/3.842 1/3.842 — 1/4.04 1/6.118 1/6.118 1/3.621 1/3.286 1/3.13 1/3.448 1/3.32 1/3.3 1/3.39 1/3.79 1/2.205	1 300 1 300 1 600 1 600 1 250 1 350 1 350 1 300 1 300 1 300 1 350 1 140 1 140 1 140 1 350 1 350 1 350 1 034 1 740 1 350 1 350 1 140 1 350 1 350 800 940 1 140 990 990 1 040	— —	130 110 130 140 90 90 90 110 60 70 80 40 40 50 85 100 100 60 90 50 50 40 70 75 40 100 80 100 90 125	This Administration did not answer this question.	1° The series 1 099 locomotive is for narrow gauge 760 mm. 2° The abbreviations for the builders signify : ABES : A group of four large Austrian firms (AEG-U, NBBC, ELIN and SSW). AEG : Allg. Elektr.-Gesellsch. Berlin. AEG-U : Aeg-Union, El.-Gesellsch. Wien. NBBC : Neue Öst. Brown-Boveri Werke Wien. ÖBBW : Öst. Brown-Boveri Werke. ELIN : Elin A.G. Wien-Weiz. Krauss & Co. : Former Lokfabr. Krauss & Co., Linz. Krauss : Lokfabr. Krauss-Maffei, Münch. Lofag : Wiener Lokfabr. A.G. Lokf. Wr.-Neust : Former Wr.-Neust. Lokfabr. SSW : Siemens-Schuck. Werke G.m.b.H. Steg : Former locomotive works of the former State Railways Company. SGP : Sim.-Graz.-Pauker A.G. 3° The reply to the question « Suspension of the motors » was not given by this Administration which indicated in its place the « Suspension of thre transmission ». 4° The diameter of the driving wheels corresponds to 70 mm tyres.
4	*BELGIUM*	*Belgian National Railways*	101 120 121 122 123	3.38 3.259 2.05 3.109 3.109	1 350 1 262 1 350 1 262 1 262	1 198 1 180 1 198 1 180 1 180	100 125 130 125 125	Series 101 : Rigid coupling with recall or centring device. Series 120 : Without coupling. Series 121 : S L M Winterthur recall or centring device. Series 122 : S L M Winterthur recall or centring device. Series 123 : S L M Winterthur recall or centring device.	
5	*BELGIUM (Colony)*	*Lower-Congo to Katanga Railway*	2 100 2 200	1/6.93 1/4.63	1 150 1 300	1 060 1 210	70 65	Series 2 100 and 2 200 : Without coupling.	

TABLE 3. — **General data concerning the various types of locomotives** *(continued)*.

Ref. No.	Country	Administrations	Type or series	Number of locomotives	Average annual mileage km	Year of construction	Builder: Mechanical part	Builder: Electrical part	Length over buffers m	Distance between outer axles m	Axle arrangement	Distance between outer axles of bogie m	Distance between bogie pivots m	Weight in running order: Mechanical part	Weight in running order: Electrical part (transmission included)	Weight per driving axle t	Weight per carrying axle t
6	*SPAIN*	*R.E.N.F.E.*	1-7	7	43 149	1 911-23	Brown-Boveri	Brown-Boveri	7.700	4.000	A-A	4.000	—	26 (total weight)		13	—
			1 000	7	26 281	1 929	C A F	C E D F (Tarbes)	11.912	8.350	Bo + Bo	2.800	—	74.8 »		18.7	—
			1 100	5	38 788	1 932	S E C N et B. & W.	General Electric Co.	12.600	8.500	Bo + Bo	2.500	—	67.5 »		16.875	—
			6 000	6	58 276	1 924	American Loc. Works	»	14.020	10.668	Co-Co	3.506	8.016	76.5 »		13.25	—
			6 100	6	58 276	1 924-25	S E C N et Baldwin	Westinghouse	14.128	10.312	Co-Co	3.962	—	75 »		12.5	—
			7 000	12	49 042	1 928	Euskalduna (Bilbao)	Oerlikon (Swizerland)	15.900	12.000	Co + Co	4.450	9.500	102 »		17	—
			7 100	25	46 312	1 929	»	»	21.000	16.400	1-Co + Co-1	4.450	9.500	111 »		15	10.5
			7 200	12	51 328	1 929	B. & W.	Brown-Boveri	24.000	20.500	2-Co + Co-2	4.300	9.750	145 »		16	12.25
			7 300	1	95 152	1 932	S E C N (Bilbao)	Metrovick	25.000	20.500	2-Co + Co-2	4.500	9.750	151.72 »		16.5	13.25
			7 400	24	67 282	1 944-50	M A C O S A (Valencia)	Ateliers de Sécheron	17.025	12.539	Co + Co	4.520	9.705	99 »		16.5	—
			7 500	12	95 152	1 944-45	C A F	B.-B. and Oerlikon	24.000	20.500	2-Co + Co-2	4.500	9.750	147 »		17	11.25
			7 600	20	25 198	1 952 and following years	Alsthom, B. & W., M T M et C A F	Alsthom and G E E	18.830	14.140	Co + Co	5.375	9.470	66	52	20	-
			7 700	56	64 621	1 954 » » »	Vulcan Foundry, Ltd.	English Electric Co.	20.657	15.417	Co + Co	4.800	10.617	120 (total weight)		20	–
			7 800	20	27 444	1 954 » » »	Westinghouse	Westinghouse	21.082	15.494	Bo + Bo + Bo	2.743	6.375	120 »		20	—
7	*FRANCE*	*French National Railways*	BB (101-180)	77	80 500	1 925-27	C G C	O E	12.580	8.740	B'o B'o	2.800	5.940	101-140 : 47.4 141-180 : 44.5	32.2	101-140 : 19.9 141-180 : 19.175	—
			BB (301-324)	23	110 850	1 938-39	A T	A T	12.930	8.950	B'o B'o	2.950	6.000	46.6	33.4	20	—
			BB (325-355)	31	86 800	1 946-48	A T-M T E	A T-M T E	12.930	8.950	B'o B'o	2.950	6.000	43.6	36.4	20	—
			BB (901-935)	34	95 350	1 936-37	A T	A T	12.870	8.950	B'o B'o	2.950	6.000	46.5	32.8	19.825	—
			BB (4 101-4 177)	43	74 600	1 928-32	C E F	C E F	12.870	8.950	B'o B'o	2.950	6.000	44	33.8	19.45	—
			BB (4 201-4 250)	46	74 600	1 934-35	A T	A T	12.870	8.950	B'o B'o	2.950	6.000	44.2	35.8	20	—
			BB (4 580-4 699)	95	61 500	1 929-32	C E F	A T	12.870	8.950	B'o B'o	2.950	6.000	44	33.8	19.45	—
			BB (4 701-4 721)	21	61 500	1 934	C E F	A T	12.870	8.950	B'o B'o	2.950	6.000	44.2	35.8	20	—
			2 D 2 (5 001-5 024)	24	148 000	1 932-38	C E F-A T	C E F-A T	16.800	13.850	2' Do 2'	2.000	11.850	72	50.5	19.125	11.5
			2 D 2 (5 105-5 120)	14	139 500	1 938-39	S C-C G C	J-S W-O E	17.780	14.400	2' Do 2'	2.400	11.740	80	50	20	1°-11.85; 2°-13.9 7°-13.1 ; 8°-11.15
			2 D 2 (5 302-5 306)	5	114 000	1 942-43	A T	A T	17.780	14.400	2' BB 2'	2.400	11.740	76	51.8	19	1° and 8°-11.9 2° and 7°-14
			2 D 2 (5 401-5 423)	22	145 000	1 937	F L	C E M	17.780	14.400	2' Do 2'	2.400	11.740	70.5	59	20	1° and 8°-11.25 2° and 7°-13.5
			2 D 2 (5 503-5 537)	35	185 000	1 933-35	»	»	17·780	14.400	2' Do 2'	2.400	11.740	85	56	20	1° and 8°-13.9 2° and 7°-16.6
			2 D 2 (5 538-5 545)	8	185 000	1 938-39	»	»	17.780	14.400	2' Do 2'	2.400	11.740	84.5	52	20	1°-13.5 ; 2°-16 7°-14.65; 8°-12.35
			2 D 2 (5 546-5 550)	5	304 600	1 942-43	»	»	17 780	14.400	2' Do 2'	2.400	11.740	80.3	51.5	20	1° and 8°-11.9 2° and 7°-14
			CC (7 101-7 143)	43	215 000	1 952-54	A T-F L	A T-C E M	18.922	14.140	C'o C'o	4.845	9.470	61	46	17.83	—
			CC (7 144-7 158)	15	215 000	1 954-55	»	»	18.922	14.140	C'o C'o	4.845	9.470	61	45	17.66	—
			BB (8 101-8 271)	171	114 000	1 949-56	A T-M T E-C G C	A T-M T E-O E	12.930	8.950	B'o B'o	2.950	6.000	With ballast 53.9 Without ballast 41.9	38.1	With ballast 23 Without bal. 20	—
			BB (9 001-9 002)	2	153 500	1 953	S L M	B B C	15.400	11.200	B'o B'o	3.600	7.700	38.7	42.1	20.2	—
			BB (9 003)	1	153 500	1 952	M T E	M T E-O E	16.200	12.400	B'o B'o	3.200	9.200	45.9	35.1	20.25	—
			BB (9 004)	1	153 500	1 954	»	M T E	16.200	12.400	B'o B'o	3.200	9.200	45.9	36.9	20.75	—
			2 D 2 (9 101-9 135)	35	225 000	1 950-51	F L	C E M	18.080	14.690	2' Do 2'	2.400	12.030	73.7	70.3	22	1° and 8°-12.8 2° and 7°-15.2
			BB (10 001)	1	59 000	1 951	A T	A T	12.954	8.950	B'o B'o	2.950	6.000	41	36 6	19.4	—
			BB (12 001-12 005)	5	163 000	1 954-55	M T E	M T E	15.200	11.400	B'o B'o	3.200	8.200	40.1	43.9	21	—
			BB (12 006-12 113)	1	163 000	1 955 and following years	»	»	15.200	11.400	B'o B'o	3.200	8.200	40.1	42.3	20.6	—
			BB (13 001-13 053)	12	146 000	1 954 » » »	»	»	15.200	11.400	B'o B'o	3.200	8.200	40.1	43.9	21	—
			CC (14 001-14 020)	3	70 000	1 955-57	C G C	O E	18.890	14.180	C'o C'o	4.670	9.510	68.55	56.45	20.83	—
			CC (14 101-14 202)	50	116 000	1 954-57	A T-F L	A T-C E M	18.890	14.180	C'o C'o	4.670	9.510	68.2	58.2	21.07	—
			CC (20 001 et 25 001-25 009)	2	132 500	1 950-57	S L M-C G C	O E	17.250	13.200	C'o C'o	4.200	9.000	51.7 53.7	52.3	17.33 17.66	—

TABLE 3.— General data concerning the various types of locomotives *(continued)*.

Ref. No.	Country	Administrations	Type or series	Nominal service voltage kV	Characteristics of the traction motor — Continuous rating — Voltage V	Continuous rating — Amperage strength A	Continuous rating — Speed t/m	Continuous rating — Speed (tyres half-worn) km/h	Hourly rating — Voltage V	Hourly rating — Amperage strength A	Hourly rating — Speed t/m	Hourly rating — Speed (tyres half-worn) km/h	Transmission	Traction motor suspension
6	SPAIN	R.E.N.F.E.	1-7	6	572	150	500	25	572	191	250	12.5	Unilateral with rigid gears	Nose-suspended
			1 000	1.65	1 650	140	1 010	32.5	1 650	200	917	29.5	» » » »	»
			1 100	1.5	750	—	487	25	750	—	478	24.5	» » » »	»
			6 000	3	1 000	215	952	35	1 000	220	944	34.7	» » » »	»
			6 100	3	1 500	125	820	38.3	1 500	152	757	35.4	» » » »	»
			7 000	1.5	500	550	897	34.5	500	715	797	31.6	» » » »	»
			7 100	1.5	500	550	897	34.5	500	715	797	31.6	» » » »	»
			7 200	1.5	750	555	654	59.5	750	650	616	56	Brown Boveri-Buchli bilateral elastic	Entirely suspended
			7 300	1.5	500	504	930	61	500	615	831	54.5	Winterthur double reduction	» »
			7 400	1.5	500	730	1 045	52	500	920	945	47	Unilateral, plain, toothed wheel, pinion	Nose-suspended
			7 500	1.5	750	680	860	65	750	835	755	60	Brown Boveri-Buchli bilateral elastic	Entirely suspended
			7 600	3	1 500	275	1 123	49	1 500	295	1 016	47.5	Alsthom system unilateral elastic	» »
			7 700	3	1 500	270	1 307	76	1 500	320	1 204	70	Unilateral plain or rigid with silent blocs	Nose-suspended
			7 800	3	1 500	265	1 002	67	1 500	285	942	63	» » » » toothed pinion	»
7	FRANCE	French National Railways	BB (101-180)	1.5	1 350	240	665	47	1 350	267	650	46	Gears	Nose-suspended
			BB (301-324)	1.5	1 350	280	525	44.5	1 350	310	505	42.5	»	»
			BB (325-355)	1.5	1 350	280	525	44.5	1 350	310	505	42.5	»	»
			BB (901-935)	1.5	1 350	265	535	42	1 350	320	500	39.5	»	»
			BB (4 101-4 177)	1.5	1 500	215	578	30.5	1 500	245	550	29	»	»
			BB (4 201-4 250)	1.5	1 500	215	578	30.5	1 500	245	550	29	»	»
			BB (4 580-4 699)	1.5	1 500	215	578	43	1 500	245	550	41	»	»
			BB (4 701-4 721)	1.5	1 500	215	578	43	1 500	245	550	41	»	»
			2 D 2 (5 001-5 024)	1.5	750 × 2	490	885	82.5	750 × 2	525	855	79.5	» with hollow shaft loose rings and springs	Entirely suspended
			2 D 2 (5 105-5 120)	1.5	675 × 2	580	825	80.5	675 × 2	690	763	74	» » » shafts and springs	» »
			2 D 2 (5 302-5 306)	1.5	675 × 2	770	735	76	675 × 2	847	715	74	» » » » Alsthom system	» »
			2 D 2 (5 401-5 423)	1.5	1 350	500	508	71	1 350	560	490	68.5	» and Buchli system	» »
			2 D 2 (5 503-5 537)	1.5	1 350	530	495	69.5	1 350	560	480	67	» » » »	» »
			2 D 2 (5 538-5 545)	1.5	1 350	530	495	69.5	1 350	560	480	67	» » » »	» »
			2 D 2 (5 546-5 550)	1.5	1 350	530	492	69	1 350	560	484	67.5	» » » »	» »
			CC (7 101-7 143)	1.5	675	850	805	71	675	910	780	69	» with hollow shaft Alsthom system	» »
			CC (7 144-7 158)	1.5	675	860	1 110	86	675	880	1 090	85	» » » » » »	» »
			BB (8 101-8 271)	1.5	675	770	645	40	675	875	605	37.5	»	Nose-suspended
			BB (9 001-9 002)	1.5	1 350	600	670	79	1 350	640	660	77.5	» and B B C disc system	Entirely suspended
			BB (9 003)	1.5	1 350	580	790	72	1 350	640	770	70	» with Jacquemin system	» »
			BB (9 004)	1.5	1 350	520	980	89	1 350	560	950	86.5	» » » »	» »
			2 D 2 (9 101-9 135)	1.5	1 350	660	455	63.5	1 350	735	437	61	» » Buchli system	» »
			BB (10 001	25	675	800	1 130	59	675	840	1 110	58	»	Nose-suspended
			BB (12 001-12 005)	25	675	1 000	890	53	675	1 080	860	51	» » Jacquemin system	Entirely suspended
			BB (12 006-12 113)	25	675	1 000	890	47.5	675	1 080	860	46	» » » »	» »
			BB (13 001-13 053)	25	13 001-15 : 250	3 000	680	53	250	3 000	680	53	» » » »	» »
					13 016-53 : 265	2 950	745	65	265	2 950	745	65		
			CC (14 001-14 020)	25	930	333	1 055	40.6	930	375	1 040	40	»	Nose-suspended
			CC (14 101-14 202)	25	590	560	1 110	28.5	590	585	1 000	25.8	» » double reduction	Partly suspended
			CC (20 001 et 25 001-25 009)	25	250	2 640	915	56	250	2 780	880	54	» and S L M system with floating rings	Entirely suspended

TABLE 3. —**General data concerning the various types of locomotives** *(continued)*.

Ref. No.	*Country*	*Administrations*	*Type or series*	*Gear ratio*	*Diameter of the driving wheels mm* — *new*	*Diameter of the driving wheels mm* — *worn*	*Maximum speed authorised* *km/h*	*Brief description of possible coupling between bogies*	*Remarks*
6	*SPAIN*	*R.E.N.F.E.*	1-7	25/112	1 195	1 135	—	Series 7 000 and 7 100 : Rigid coupling with spherical ball point. Series 7 200, 7 300 and 7 500 : Longitudinal bar with springs at ends for traction and transverse bar with recall or recentring spring. Series 7 400 : Longitudinal bar with springs at ends for traction and rigid transversal bar. Series 7 700 : Helical spring housed in a holder suspended from the body. The drawbar of the spring and opposited end of the holder are articulated at the highest points of two triangular frames rigidly connected to each bogie respectively.	1° The locomotives series 7 600, 7 700 and 7 800 were still being delivered at the 31st December 1955, so that the average annual mileage is not representative; it should reach a figure of the order of 95 000 km. 2° The abbreviations used for the builders signify : CAF : Compañia Auxiliar de Ferrocarriles. SECN : Sociedad Española de Construcción Naval. B. & W.: Sociedad Española de Construcciones Babcock & Wilcox. MCOSA : Material y Construcciones. MTM : Maquinista Terrestre y Maritima (Barcelona).
			1 000	16/75	1 400	1 340	65		
			1 100	19/88	1 270	1 210	70		
			6 000	18/72	990	930	60		
			6 100	18/61	990	930	70		
			7 000	17/84	1 300	1 240	90		
			7 100	17/84	1 300	1 240	90		
			7 200	35/120	1 050	1 590	110		
			7 300	1/4.484	1 560	1 500	110		
			7 400	1/4.94	1 300	1 240	100		
			7 500	35/120	1 560	1 500	110		
			7 600	20/63	1 250	1 190	125		
			7 700	16/63	1 220	1 160	110		
			7 800	20/63	1 118	1 058	130		
7	FRANCE	*French National Railways*	BB (101-180)	3.47	1 350	1 290	90	Series BB (156-180) : The recentring mechanism between bogies consists of bars connected by a set of helical springs. Initial torque in relation to pivot 1 075 kgm. Series BB (301-355; 901-935; 8 101-8 271 and 10 001) : The recentring system consists of two projecting members like buffers and a set of levers with eight helical springs. Initial torque in relation to pivot approx. 3 000 kgm. Series BB (4 101-4 177 and 4 582-4 699) : The recentring system consists of two projecting members in the form of buffers and two volute springs. Initial torque in relation to pivot 2 730 kgm. Series BB (4 201-4 250 and 4 701-4 720) : The recentring device consists of two projecting members in the form of buffers, four helical springs and two leaf springs. Initial torque in relation to pivot 5 000 kgm. Series BB (9 001-9 002) : The connection between bogies is assured by bars and two helical springs for the lateral recentring and a helical spring for the vertical recentring. Initial transversal torque 6 900 kgm; initial vertical torque : 2 300 kgm.	The abbreviations used for the builders signify : CGC : Cie Générale de Construction de Locomotives (Batignolles Chatillon). OE : Société Oerlikon. AT : Alsthom. MTE : Cie de Matériel de Traction Electrique. CEF : Société de Constructions Electriques de France. SC : Schneider et Cie. J : Société des Forges et Ateliers de Constructions électriques de Jeumont. SW : Société de Matériel électrique SW. FL : Compagnie de Fives-Lille. CEM : Compagnie Electro-Mécanique. SLM : Société Suisse pour la construction de Locomotives et de Machines. BBC : Société Brown-Boveri.
			BB (301-324)	2.916	1 350	1 290	105		
			BB (325-355)	2.916	1 350	1 290	105		
			BB (901-935)	3.27	1 400	1 340	95		
			BB (4 101-4 177)	4.875	1 400	1 330	65		
			BB (4 201-4 250)	4.875	1 400	1 330	65		
			BB (4 580-4 699)	3.475	1 400	1 330	90		
			BB (4 701-4 721)	3.475	1 400	1 330	90		
			2 D 2 (5 001-5 024)	3.468	1 750	1 680	100		
			2 D 2 (5 105-5 120)	3.333	1 750	1 690	110		
			2 D 2 (5 302-5 306)	3.148	1 750	1 690	100		
			2 D 2 (5 401-5 423)	2.311	1 750	1 690	140		
			2 D 2 (5 503-5 537)	2.311	1 750	1 690	140		
			2 D 2 (5 538-5 545)	2.311	1 750	1 690	140		
			2 D 2 (5 546-5 550)	2.311	1 750	1 690	140		
			CC (7 101-7 143)	2.606	1 250	1 190	150		
			CC (7 144-7 158)	2.96	1 250	1 190	150		
			BB (8 101-8 271)	4.143	1 400	1 350	105		
			BB (9 001-9 002)	2.02	1 300	1 240	140		
			BB (9 003)	2.517	1 250	1 190	140		
			BB (9 004)	2.517	1 250	1 190	140		
			2 D 2 (9 101-9 135)	2.311	1 750	1 700	140		
			BB (10 001)	4.375	1 250	1 190	100		
			BB (12 001-12 005)	3.842	1 250	1 190	120		
			BB (12 006-12 113)	4.294	1 250	1 190	120		
			BB (13 001-13 053)	2.92 et 2.607	1 250	1 190	105 et 120		
			CC (14 001-14 020)	5.187	1 100	1 040	60		
			CC (14 101-14 202)	3.75 et 2.83	1 100	1 040	60		
			CC (20 001 et 25 001-25 009)	4.19	1 400	1 330	100		

TABLE 3. — **General data concerning the various types of locomotives** *(continued)*.

Ref. No.	Country	Administrations	Type or series	Number of locomotives	Average annual mileage km	Year of construction	Builder: Mechanical part	Builder: Electrical part	Length over buffers m	Distance between outer axles m	Axle arrangement	Distance between outer axles of bogie m	Distance between bogie pivots m	Weight in running order: Mechanical part	Weight in running order: Electrical part (transmission included)	Weight per driving axle t	Weight per carrying axle t
8	*HOLLAND*	*Netherlands Railways*	1 000	10	94 931	1 948-49	Winterthur and Werkspoor	Oerlikon and Heemaf & E T I	16.220	11.890	(1 A) Bo (A 1)	2.600	8.990	60	40	18	14
			1 100	50	146 215	1 950-51-52	Alsthom	Alsthom	12.984	8.950	B'o B'o	2.950	6.000	46	34	20	—
			1 200	25	148 799	1 951-52-53	Werkspoor	Heemaf	18.085	13.870	C'o C'o	4.724	8.994	68	40	18	—
			1 300	10	167 647	1 952-53	Alsthom	Alsthom	18.952	14.140	C'o C'o	4.845	9.470	61	50	18.5	—
9	*ITALY*	*Italian State Railways*	E 326	12	112 220	—	—	—	—	—	—	—	—	—	—	—	—
			400	3	29 990	—	Ansaldo	Ansaldo	—	—	—	—	—	—	—	—	—
			424	157	86 520	1 943	Brown-Boveri	Brown-Boveri	15.500	—	Bo Bo	3.150	7.350	46	26	18.1	—
			428	240	146 380	1 934-40	Breda	Breda	19.000	—	2 Bo Bo 2	2.200	6.850	89	46	19.5	14.25
			626	419	80 000	1 927-39	Savigliano	Savigliano	14.900	—	Bo Bo Bo	2.450	4.250	56	37	15.35 and 15.8	—
			636	177	67 030	1 940 and following years	Reggiane	Marelli	18.250	—	Bo Bo Bo	3.150	5.200	63	38	16.7 and 16.9	—
			621	5	21 970	—	O M	C G E	—	—	—	—	—	—	—	—	—
			434	1	86 520	—	—	—	—	—	—	—	—	—	—	—	—
10	*ITALY*	*North Milan Railways*	600	6	74 400	1 920-30	O M-Milano	C G di E	11.920	—	Bo + Bo	1.810	5.600	62 (total weight)		15.5	—
			610	4	74 400	1 949	id. R. Breda	»	14.200	—	Bo + Bo	2.150	6.600	61 »		15.25	—
			700	21	139 420	1-14 = 1 928-30 15-21 = 1 940-42	O M-Milano Tallero	T I-B B id.-Nord Milano	20.600	—	Bo + Bo	2.190	13.900	55 »		13.75	—
			750	1	128 916	1 937	S.A. Piaggio e C.	C G di E	68.160	—	Bo + Bo	2.190	16.020	96 »		11.5	—
			730	3	141 900	1 940	Tallero	T I-B B	20.600	—	Bo + Bo	2.190	13.900	57 »		14.25	—
			740	16	142.200	1- 7 = 1 951 8-16 = 1 953-55	» Breda	» C G di E-T I-B B	20.600 22.720	—	Bo + Bo Bo + Bo	2.190 2.190	13.900 16.020	57 » 51 »		14.25 12.75	— —
11	*U.S.S.R.*	*U.S.S.R. Railways*	N 8	—	—	1 953-55 and following years	—	—	27.520	24.200	0-30 + 30-0	3.200	7.100	180 (total weight)		22.5	—
			V L 22^{M}	—	—	1 941-46 and following years	—	—	16.390	12.200	0-20 + 20 + 20 + 20-0	4.200	8.580	132 »		22	—
12	*SWITZERLAND*	*C.F.F.*	Re 4/4	50	186 000	1 946-51	S L M	B B C-M F O-S A A S	14.700	10.800	B'o-B'o	3.000	7.800	34	24	14.5	—
			Ae 3/6^{II}	60	99 000	1 924-26	»	M F O	14.090	10.800	2' C 1'	—	—	54 and 56	44 and 40	18.8	13.5
			Ae 3/6^{I}	114	102 000	1 921-29	»	B B C-M F O-S A A S	14·700	10·700	2' C 1'	—	—	52 and 53	42 and 42	18.7	13.2
			Ae 4/6	12	208 000	1 941-45	»	»	17.260	12.200	(1 Ao) Ao + Ao (Ao 1)	—	—	56 and 59	49 and 46	19.9	12.8
			Ae 4/7	127	153 000	1 927-34	»	»	16.760	12.680	2' Do 1'	—	—	64 and 63	54 and 57	19.9	14.8
			Ae 6/6	14	233 000	1 952-56	»	B B C-M F O	18.400	13.000	C'o-C'o	4.300	8.700	66	54	20	—
			Be 4/6	42	96 000	1 919-23	»	B B C	16.500	13.500	1 B-B 1	5.200	10.950	59 and 60	48 and 50	20	15
			Be 6/8^{III}	18	139 000	1 926-27	»	M F O	20.060	17.000	1 C + C 1	6.650	6.320	78	53	17.6	11.6
			B Fe 4/4	31	121 000	1 952-55	S L M-S W P	B B C-M F O-S A A S	22.700	19.050	B'o-B'o	2.800	16.250	35 and 37	20 and 21	16.5	—
13	*SWITZERLAND*	*Rhaetian Railway*	351-355	5	34 300	1 913-14	S L M Winterthur	M F O Zch-Oerlikon	11.000	8.200	1 D 1	—	—	29	24	10.5	6
			401-415	15	73 500	1 921-29	»	M F O Oerli/B B C Baden	13.300	10.350	C C	3.275	5.670	38	28	11	—
			601-610	10	118 000	1 947-53	»	»	12.100	8.700	Bo Bo	2.500	6.200	25.5	21.5	12	—
14	*TURKEY*	*State Railways*	Bo Bo	3	—	1 955	Alsthom	Jeumont	16.138	11.200	Bo Bo	8.000	—	47.04	30.46	20	—
15	*YUGOSLAVIA*	*Yugoslavian Railways*	B'o Bo B'o	17	81 300	1 935	Breda, T I B B, C G E, Savigliano		14.950	11.550	B'o Bo B'o	2.450	—	95 (total weight)		16	—

TABLE 3. — **General data concerning the various types of locomotives** *(continued)*.

Ref. No.	Country	Administrations	Type or series	Nominal service voltage kV	Characteristics of the motor when running: Continuous rating: Voltage V	Continuous rating: Amperage A	Continuous rating: Speed t/m	Continuous rating: Speed (tyres half-worn) km/h	Hourly rating: Voltage V	Hourly rating: Amperage A	Hourly rating: Speed t/m	Hourly rating: Speed (tyres half-worn) km/h	Transmission	Traction motor suspension
8	*HOLLAND*	*Netherlands Railways*	1 000	1.5	675	580	—	108	675	660	—	101.4	S I M Universal double reduction type	In the body
			1 100	1.5	675	780	—	77.5	675	820	—	68.4	Hollow shaft and Alsthom Silent blocs	At three points in the bogie
			1 200	1.5	675	585	—	74.6	675	630	—	72	Rigid	By the nose and on the axle
			1 300	1.5	675	780	—	77.5	675	820	—	68.4	Hollow shaft and Alsthom Silent blocs	At three points on the bogie
9	*ITALY*	*Italian State Railways*	E 326	—	—	—	—	—	—	—	—	—	—	—
			400	—	—	—	—	—	—	—	—	—	—	—
			424	3	1 500	233	940	60	1 500	260	900	53	Hollow shaft with spring leaf	Rigidly fastened to the frame
			428	3	1 500	200	750	74/80/91	1 500	233	700	69.5/76/86	» » » » »	» » » »
			626	3	1 500	200	750	48/57	1 500	233	700	45/54	Direct	Tramway type
			636	3	1 500	200	750	56/75	1 500	233	700	52.5/70	Hollow shaft with spring leaf	Rigidly fastened to the frame
			621	—	—	—	—	—	—	—	—	—	—	—
			434	—	—	—	—	—	—	—	—	—	—	—
10	*ITALY*	*North Milan Railways*	600	3	3 000/2	—	—	—	3 000/2	210	630	40	—	—
			610	3	3 000/2	—	—	—	3 000/2	210	630	40	—	—
			700	3	2 700/2	84	900	60	2 700/2	110	790	54	—	—
			750	3	2 700/2	84	900	60	2 700/2	110	790	54	—	—
			730	3	2 700/2	119	925	59	2 700/2	160	830	53	—	—
			740	3	2 700/2	119	925	59	2 700/2	160	830	53	—	—
				3	2 700/2	119	925	59	2 700/2	160	830	53	—	—
11	*RUSSIA*	*U.S.S.R. Railways*	N 8	3	470	340	765	44.3	525	380	735	42.6	Carrying axle	—
			V L 22M	3	310	225	750	38, 45 and 61	400	240	710	36, 43 and 58	Tramway type	—
12	*SWITZERLAND*	*C.F.F.*	Re 4/4	—	374	1 470	1 065	88	374	1 470	1 000	83	B B C elastic system	Carrying arms
			Ae 3/6II	—	380	2 000	540	75	380	2 000	475	65	Rods	—
			Ae 3/6I	—	390	1 550	585	69	390	1 700	550	65	B B C elastic system	—
			Ae 4/6	—	430	1 300	1 110	88	430	1 380	1 070	85	Universal flexible system	Fastened to the frame
			Ae 4/7	—	405	1 740	560	66	405	1 780	550	65	B B C elastic system	—
			Ae 6/6	—	390	1 900	835	75.5	390	2 120	775	70	» » »	—
			Be 4/6	—	505	850	620	56	505	1 050	575	52	Rods	—
			Be 6/8III	—	364	1 400	616	38	364	1 600	567	35	»	—
			B Fe 4/4	—	430	700	1 445	76	430	800	1 330	70	B B C and S A A S flexible systems	Carrying arms
13	*SWITZERLAND*	*Rhaetian Railways*	351-355	11	300	800	730	33	300	1 200	640	29	Rods driving shafts and pinions	Suspended to the frame
			401-415	11	520	900	630	30.8	520	1 050	600	29.2	» » » » »	» » »
			601-610	11	400	710	1 400	50.3	400	840	1 275	45.7	B B C flexible	Nose-suspended
14	*TURKEY*	*Turkish State Railways*	Bo Bo	25	300	1 780	—	62.5	300	1 880	—	60.3	Toothed pinion wheel	At three points on rubber
15	*YUGOSLAVIA*	*Yugoslavian Railways*	B'o Bo B'o	2.4-3.4	1 350	267	—	42.5	1 350	281	—	42.5	Unilateral gears	Tramway type

TABLE 3. — **General data concerning the various types of locomotives** *(continued)*.

Refer. No.	Country	Administrations	Type or series	Gear ratio	Diameter of the driving wheels mm — new	Diameter of the driving wheels mm — worn	Maximum speed authorised km/h	Brief description of possible coupling between bogies	Remarks
8	*HOLLAND*	*Netherlands Railways*	1 000	42/75 ∧ 53/106	1 550	1 470	135	Series 1 100 : Drawbar :	Locomotive series 1 300 : bogie centre. There are two pivots per bogie 1 167 mm from the centre.
			1 100	20/74	1 250	1 170	135		
			1 200	20/71	1 100	1 020	135		
			1 300	20/74	1 250	1 170	135		
9	*ITALY*	*Italian State Railways*	E 326	—	—	—	—		Series E 428 : The distance between bogie pivots is measured between the pivots of the outer bogies and that of the articulation of the two half frames. Series E 626 : The distance between bogie pivots is measured between the bogie pivot and that of the articulation connection to the body. Series E 636 : A transmission with double hollow shaft and elastic buffers of rubber is being tried. The different speeds depend upon the ratio of the transmission.
			400	—	—	—	—		
			424	16/65	1 250	1 170	100	Without coupling, the bogie bolster being moved transversely by 70 mm.	
			428	29/103-31/101-34/98	1 880	1 800	130	Pivots moved transversely 200 mm. Frame of body in two articulated parts with spherical centre.	
			626	21/76-24/73	1 250	1 170	95	Bogies connected to frame by triangular crossmember with ball joint. Radial displacement of 200 mm.	
			636	21/65-28/65	1 250	1 170	120	Without coupling, with transversal movement of bogie bolster of 70 mm.	
			621	—	—	—	—		
			434	—	—	—	—		
10	*ITALY*	*North Milan Railways*	600	74/20	1 250	1 180	75	Series 600 : Spherical ball joint.	The abbreviations used for the builders signify : OM : Officine Meccaniche. C.G. di E. : Comp. Generale di Elettricità. TI-BB : Tecnomasio Italiano-Brown-Boveri.
			610	74/20	1 250	1 180	75		
			700	67/24	1 000	950	80		
			750	67/24	1 000	950	80		
			730	68/23	1 000	950	80		
			740	68/23	1 000	950	80		
				68/23	1 000	950	80		
11	*U.S.S.R.*	*U.S.S.R. Railways*	N 8	82/21	1 200	1 120	100	In the two series, the bogies are connected by pivots.	
			V L 22^{M}	88/20-86/23 and 80/29	1 200	1 120	90 to 120		
12	*SWITZERLAND*	*C.F.F.*	Re 4/4	1/2.31	1 040	980	125	Series Re 4/4 and Ae 6/6 : Elastic transversal coupling. Series Be 4/6 and Be $6/8^{III}$: Fixed transversal coupling.	
			Ae $3/6^{II}$	1/2.224	1 610	1 530	100		
			Ae $3/6^{I}$	1/2.57	1 610	1 550	110		
			Ae 4/6	1/3.22	1 350	1 290	125		
			Ae 4/7	1/2.57	1 610	1 550	100		
			Ae 6/6	1/2.56	1 260	1 190	125		
			Be 4/6	1/3.2	1 530	1 465	75		
			Be $6/8^{III}$	1/4.03	1 350	1 270	75		
			B Fe 4/4	1/3.26	940	880	100		
13	*SWITZERLAND*	*Rhaetian Railway*	351-355	1/4.3	1 070	990	55	Series 601-610 : S L M type transversal coupling.	
			401-415	1/4.13	1 070	990	55		
			601-610	1/5.44	1 070	990	65		
14	*TURKEY*	*State Railways*	Bo Bo	79/16	1 350	—	90		
15	*YUGOSLAVIA*	*Yugoslavian Railways*	B'o Bo B'o	73/24	1 250	1 175	95	The end bogies are connected to the centre bogie by pins limiting the vertical displacement.	

TABLE 4. — From information received, it results that all Administrations use braking by friction by means of cast iron shoes on the tyres. Some others use also electric and rheostatic braking on certain types and regenerative braking on others, according to the following particulars:

No.	Country	Administrations	
1	*WESTERN GERMANY*	*Deutsche Bundesbahn*	Rheostatic braking used on locomotives types E. 44 and E. 94.
2	*ALGERIA*	*Algerian Railways*	Regenerative braking used on locomotives types CC. 6 AE.
3	*AUSTRIA*	*Austrian Railways*	On types of locomotives 1020 - 1040 - 1041, 1045 - 1145 (01 - 08), 1245 (509 - 518, 529 - 541) use is made of electric rheostatic braking, exciting by A.C. current. Series 1180 uses rheostatic electric braking with exciting by D.C. current.
5	*BELGIUM (Colony)*	*Lower Congo to Katanga Railway*	Electric rheostatic braking is used on all types of locomotives.
6	*SPAIN*	*R.E.N.F.E.*	On types of locomotives 6000 - 6100 - 7000 - 7200 - 7300 - 7100 - 7400 - 7500 - 7600 - 7700 and 1/7 use is made of regenerative electrical braking. On series 1000 and 7800 use is made of rheostatic braking.
7	*FRANCE*	*French National Railways*	Rheostatic and regenerative braking is used on locomotives running on heavy gradients.
9	*ITALY*	*Italian State Railways*	On all types of locomotives 42.4003 - 13, regenerative electric braking is used.
10	*ITALY*	*North Milan Railway*	Rheostatic braking is used on all types of locomotives.
11	*U.S.S.R.*	*U.S.S.R. Railways*	On all types of locomotives N 8 and VL. 22 M. regenerative electric braking is used.
12	*SWITZERLAND*	*C.F.F.*	On all types of locomotives Re. 4/4-Ae. 4/6, Ae. 4/7-Ae. 6/6, Be. 4/6-Be. 6/8 III, BFe. 4/4 use is made for the 1st series, partly regenerative; for the 2nd series, regenerative; for the 3rd series, partly regenerative; for the 4th, regenerative; for the 5th series, partly regenerative; for the 6th, regenerative and for the 7th, rheostatic.
13	*SWITZERLAND*	*Rhaetian Railway*	On these types of locomotives 1-D. 1, C.C., B.B. Electric braking is used regenerative (M F O), rheostatic, regenerative (M F O).

TABLE 5.

No.	Country	Administrations	Max. speeds authorised for passenger trains km/h	Approx. normal speed of passenger trains (stops not included) km/h	Approx. normal speed of freight trains km/h
1	*WESTERN GERMANY*	*Deutsche Bundesbahn*	120	Long distance 90 Mail . . . . 53 Fast 77	41
2	*ALGERIA*	*Algerian Railways*	90	65	40
3	*AUSTRIA*	*Austrian Railways*	Express . . 100 Mail . . . . 80 Motor coaches 110	A little less than the max. speed	60
4	*BELGIUM*	*Belgian National Railways*	90 to 140	Through 100 Omnibus 50/60	50 to 80
5	*BELGIUM (Colony)*	*Lower Congo to Katanga Railway* . .	45 to 60	50	40
6	*SPAIN*	*R.E.N.F.E.*	100 to 110	Talgo . . . . 90 Express . . . 70 Mail 60	35 to 40
7	*FRANCE*	*French National Railways*.	140 150 since 2-6-57	Fast . . . . 120 Express through 100 Omnibus . . 80	50
8	*HOLLAND*	*Netherlands Railways*	125	100 to 120	45 to 90
9	*ITALY*	*Italian State Railways*	120	60 to 110	55 to 80
10	*ITALY*	*North Milan Railways*	80	50 to 80	20 to 50
11	*U.S.S.R.*	*U.S.S.R. Railways*	100 to 120	—	—
12	*SWITZERLAND*	*C.F.F.*	125	110	65 max.
13	*SWITZERLAND*	*Rhaetian Railway*	65	35 to 42	30
14	*TURKEY*	*Turkish State Railways*	90	60	60
15	*YUGOSLAVIA*	*Yugoslavian Railways*	55/65	45 to 65	45

All these increases in the electrification of the lines have generally been accompanied by corresponding purchases of new motor stock.

To complete the picture of the extension of electrification in the different countries consulted, we asked the Administrations to indicate the ratio between the tons-km for electric traction and steam traction. The results are shown in *Table 2*.

This table shows that there are some railways, such as the Algerian Rys. on which all the traffic is worked by electric traction. On the Netherlands and Italian Rys. electric traction is responsible, respectively for four times and twice as much work as steam traction, and on the other Administrations shown in the table in question, the work done by electric traction is definitely lower than that assured by steam traction, according to the degree to which these systems have been electrified.

Table 3 shows for each of the Administrations, the type and series of electric locomotives owned, their number, average annual mileage, year of construction, name of builder and principal characteristics, for example : length over buffers, axle spacing, arrangement of axles, weight in working order, load per driving axle and per carrying axle.

In the same table, we have included the principal characteristics of the traction motors at the hourly and continuous rating respectively. The method of transmitting the power from the motor to the axle is also shown, as well as the diameter of the driving wheels, the maximum speed allowed and a brief indication of the general connections between bogies.

Table 4 includes data concerning the types of brakes used by the different Administrations on their locomotives. This shows that all the Administrations make use of friction brakes by means of cast iron shoes applied against the tyres. Some types of locomotives are also equipped with rheostatic braking, and others with regenerative braking.

Table 5 is devoted to the speeds of the passenger and freight trains. The maximum speed allowed in km/h is given for the former, the approximate standard running speeds for these same trains, allowing for the stops, and the approximate average running speed of the freight trains.

An examination of this table shows that the *maximum speeds authorised* for passenger trains on most Administrations is usually 100 to 120 km/h.

Above these figures are the S.N.C.F. which since June 1957 has authorised a speed of 150 km/h, Belgium which also authorises 140 km/h, Germany, Italy, Holland, Russia and Switzerland (C.F.F.) with 120 km/h. On the other hand, Algeria, the Lower Congo, North-Milan, Rhaetian Ry. and Jugoslavian Rys. are under 90 km/h.

As regards the *approximate running speed* of the passenger trains, the differences are less appreciable, and it can be taken that for the long distance trains the usual speed is 100 to 110 km/h for the large Administrations, such as Germany, Belgium, Spain, France, Holland, Italy and Switzerland. The others have normal speeds of 50 to 60 km/h.

Finally as regards the *approximate normal running speed* of the freight trains, this varies relatively little, and is about 45 to 50 km/h. Higher figures than these are only found on the Austrian, Belgian, Dutch, Italian, Swiss and Turkish railways.

II.

II. WEAR OF TYRES (INFLUENCE OF THE WEAR OF WHEELS, AXLE LOADS, SPEED, TYPE OF BOGIE, AND POSSIBLY UNDULATORY WEAR OF THE RAILS).

Table 6 sums up the replies received concerning the wear of tyres.

1. Monobloc wheels.

As shown in the table in question, none of the Administrations replying to the questionnaire uses monobloc wheels on its electric locomotives, except Germany who uses cast steel wheels, on account of their special profile and the driving gear. Experience acquired by this Administration with the use of these cast steel wheels is generally good, apart from a few cracks due to high loads.

TABLE 6. — **General data concerni**

Ref. No.	Country	Administrations	*None of the Administrations use monobloc wheels on their electric locomotive the steel used for rails and the tyres of locomotive wheels has not been altere the characteristics : the former in 1930 by altering R = 70-80 kg/mm² a special steel.*					
			Chemical analysis					
			C %	*Mn* %	*Si* %	*P* %	*S* %	*Remarks*
1	*WESTERN GERMANY*	*Deutsche Bundesbahn*	0.37-0.55 0.50-0.70	0.70-1.20 0.70-1.20	0.07-0.35 0.15-0.35	0.08 < 0.05	0.06 < 0.05	Thomas Siemens-Martin
2	*ALGERIA*	*Algerian Railways*	—	—	—	—	—	—
3	*AUSTRIA*	*Austrian Railways*	0.40-0.55 0.50-0.65	0.80-1.20 1.70-1.90	0.07-0.35 0.10-0.35	< 0.05 < 0.02	< 0.05 < 0.02	Normal quality Quality with Mn
4	*BELGIUM*	*Belgian National Railways*	0.40-0.55	0.70-1.20	0.10-0.30	< 0.08	< 0.06	—
5	*BELGIUM (Colony)*	*Lower Congo to Katanga Railway*	0.40-0.55	0.70-1.20	0.10-0.30	< 0.08	< 0.06	—
6	*SPAIN*	*R.E.N.F.E.*	0.45-0.57 0.50-0.60	0.90-1.20 0.90-1.20	0.15-0.20 0.15-0.20	< 0.065 < 0.015	< 0.06 < 0.06	Thomas-Bessemer Martin-Siemens
7	*FRANCE*	*French National Railways*	0.40-0.50	0.90-1.15	0.06-0.16	0.07-0.085	0.02-0.04	Works analysis No specification laid down

The table shows that the chemical composition of steels used for rails varies between :

C — 0.37-0.82
Mn — 0.70-1.90
Si — 0.06-0.35
P — 0.02-0.09
S — 0.02-0.07

As regards the mechanical characteristics of these steels, those used for rails vary between :

R 55-90 kg/mm

used for the rails and tyres.

ne Deutsche Bundesbahn which uses cast steel wheels on account of the special profile and running gear. The quality of compared with steam traction. Only in the case of the tyres have the C.F.F. (Switzerland) and F.S. (Italy) modified /mm², A = 13 % to A = 14 % and L = 10 d to L = 5 d (test pieces), and the latter by using on the fast light trains

Mechanical characteristics					
...stance to ...aking ...ough ...ction	*Coefficient of quality*	*Apparent limit of elasticity to tension*	*Minimum resilience*	*Brinell hardness*	*Remarks* *R — tensile breaking load* *A = elongation at fracture %*
kg/mm² ...nd 90 mm²	· 104	—	—	210-320 Hb	—
kg/mm²	—	—	—	—	—
kg/mm² kg/mm²	> 104 > 116	40-45 kg/mm² 50-55 kg/mm²	— —	— —	Coefficient of quality = R + 2.2 A.
k /mm²	> 104	—	—	70-85 kg/mm²	Coefficient of quality = R + 2.2 A.
kg mm²	> 104	38-44 kg mm²	—	—	Coefficient of quality = R + 2.2 A. The resilience test is carried out by dropping a weight of 1 000 kg from a height of 6 m on the head of a section of rail 2 m long, supported at two points 1 m apart. The rail must stand up to one such blow without breaking or cracking.
kg/mm²	> 98	> 35 kg/mm²	Not imposed	> 207	Coefficient of quality = 2 R + A. Brinell hardness : Diameter of the ball = 10 mm. Load = 3 000 kg.'. Application = 30''
kg mm²	> 104	Not imposed	Not imposed	Not imposed	Coefficient of quality = R + 2.2 A. Brinell hardness : Diameter of the ball 10 mm. Load = 3 000 kg. Application = 10''.

. of the tyres : C = 0.50-0.75
Mn = 0.41-1.20
S = 0.15-0.50
P < 0.02-0.07
S < 0.02-0.07

of the tyres : R = 75-105 kg/mm². For the other mechanical characteristics, no limits are given because many Administrations do not impose any.

TABLE 6. — **General data concern**

Ref. No.	Country	Administrations	*None of the Administrations use monobloc wheels on their electric locomotiv the steel used for rails and the tyres of locomotive wheels has not been alte the characteristics : the former in 1930 by altering R = 70-80 kg/mm² a special steel.*					
			Chemical analysis					
			C %	*Mn* %	*Si* %	*P* %	*S* %	*Remarks*
1	*WESTERN GERMANY*	*Deutsche Bundesbahn*	0.59-0.73	0.41-0.84	0.25-0.39	0.02-0.05	0.02-0.04	
2	*ALGERIA*	*Algerian Railways*	0.75	< 1.20	—	< 0.25	< 0.05	N² < 0.50 STU 14 A 75 steel
3	*AUSTRIA*	*Austrian Railways*	0.65	0.65	0.30	< 0.04	< 0.035	P + S < 0.06
4	*BELGIUM*	*Belgian National Railways*	—	< 1.00	—	< 0.05	< 0.05	P + S < 0.10
5	*BELGIUM (Colony)*	*Lower Congo to Katanga Railway*	—	—	—	< 0.04	< 0.04	P + S < 0.07
6	*SPAIN*	*R.E.N.F.E.*	—	—	—	< 0.05	< 0.05	P + S < 0.09 Martin-Siemens st or electric, acid or basic
7	*FRANCE*	*French National Railways*	—	—	—	< 0.05	< 0.05	Apart from exce tional cases, no chemical analysi is imposed and o P + S < 0.09

The table shows that the chemical composition of steels used for rails varies between :

C = 0.37-0.82
Mn = 0.70-1.90
Si = 0.06-0.35
P < 0.02-0.09
S < 0.02-0.07

As regards the mechanical characteristics of these steels, those used for rails vary between :

R = 55-90 kg/m

used for the rails and tyres *(continued)*.

e Deutsche Bundesbahn which uses cast steel wheels on account of the special profile and running gear. The quality of compared with steam traction. Only in the case of the tyres have the C.F.F. (Switzerland) and F.S. (Italy) modified mm², A = 13 % to A = 14 % and L = 10 d to L = 5 d (test pieces), and the latter by using on the fast light trains

Mechanical characteristics						
…stance …o …king …ugh …tion	*Coefficient of quality*	*Apparent limit of elasticity to tension*	*Minimum resilience*	*Brinell hardness*	*Remarks* *R = tensile breaking load* *A = elongation at fracture %*
…kg/mm²	Not imposed	—	1.3-2.1 kgm/cm²	210-254 kg/mm² (Hb 30)	—
…kg/mm²	> 50 A < 14 %	—	—	—	—
…kg/mm²	—	—	—	—	Use is made of the specifications of the German Railways (D.B.) (91.857 I 49).
…kg/mm²	[illegible] 107	Not imposed	[illegible] 1.5 kgm/cm²	Not imposed	Coefficient of quality = R + 2.2 A. Length of the test piece [illegible] 6 [illegible]. For the resilience ISO test piece with a notch of 5 mm and rounded at ⌀ = 2 mm.
…kg/mm²	A [illegible] 8.5 %	57-61 kg/mm²	[illegible] 2 kgm/cm²	Not imposed	The elongation defining the coefficient of quality is measured over a length of five times the diametre of the test piece. The notch in the resilience test piece is 5 mm (I.S.A. test piece) or 2 mm (Mesnager). The minimum of K remains the same. These figures naturally are the average for two test pieces.
…kg/mm²	—	—	> 3 kgm/cm²	—	The resilience test is made on three test pieces of 55 × 10 × 10 mm. Mesnager notch.
…kg/mm²	Not imposed A > 12 %	Not imposed	2 kgm/cm²	Difference between the numbers of a same cast ≤ 40	Brinell hardness : Diameter of the ball [illegible] 10 mm. Load = 3 000 kg. Application = 15 seconds.

…: of the tyres : C = 0.50-0.75
Mn = 0.41-1.20
Si = 0.15-0.50
P < 0.02-0.07
S < 0.02-0.07

…t of the tyres : R = 75-105 kg/mm². For the other mechanical characteristics, no limits are given because many Administrations do not impose any.

Ref. No.	Country	Administration	[illegible] — Chemical analysis: C %	Mn %	Si %	P %	S %	Remarks
8	HOLLAND	Netherlands Railways	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Thomas Bessemer aci Siemens-M. bas Siemens-M. aci Electric
9	ITALY	Italian State Railways	[illegible]	1.15	0.22	0.035	0.045	—
10	ITALY	North Milan Railway	[illegible]	~ 1.2	[illegible]	[illegible]	[illegible]	—
11	U.S.S.R.	U.S.S.R. Railways	0.59-0.82 0.67-0.80	0.70-1.0 0.70-1.0	0.13-0.28 0.13-0.28	< 0.04 < 0.04	< 0.05 < 0.05	Steel brand M Steel brand M
12	SWITZERLAND	C.F.F.	0.37-0.55	< 0.9	0.07-0.35	< 0.06	< 0.06	—
13	SWITZERLAND	Rhaetian Railways	—	—	—	—	—	Not imposed
14	TURKEY	Turkish State Railways	—	—	—	—	—	Quality Thomas Bessemer or Siemens-Martin
15	YUGOSLAVIA	Yugoslavian Railways	0.45-0.60	0.70-1.20	0.07-0.35	< 0.06	< 0.06	P + S = [illegible]

The table shows that the chemical composition of steels used for rails varies between :

C = 0.37-0.82
Mn = 0.70-1.90
Si = 0.06-0.35
P = 0.02-0.28
S = 0.02-0.07

As regards the mechanical characteristics of these steels, those used for rails vary between :

R = 55-90 kg

...sed for the rails and tyres *(continued)*.

... Deutsche Bundesbahn which uses cast steel wheels on account of the special profile and running gear. The quality of ... compared with steam traction. Only in the case of the tyres have the C.F.F. (Switzerland) and F.S. (Italy) modified ...nm², A = 13 % to A = 14 % and L = 10 d to L = 5 d (test pieces), and the latter by using on the fast light trains

			Mechanical characteristics		
...ance ... ...king ...ugh ...ion	*Coefficient of quality*	*Apparent limit of elasticity to tension*	*Minimum resilience*	*Brinell hardness*	*Remarks* *R = tensile breaking load* *A = elongation at fracture %*
...g/mm² ...g/mm²	< 104 > 108 (electric)			200-243 < 200 $(Hb = \frac{R}{0.35})$	Quality coefficients : K = 11.2 : R + 2.7 A. K = 8.16 : R + 2.5 A. K = 5.65 : R + 2.2 A K = 4 : R + 2 A L = K $\sqrt{So}$ (L = length). So = initial section.
...g/mm²	= 750	40 kg/mm²	2 kgm/cm²	225	Coefficient of quality R × A 750 with cylindrical test piece 20 mm ∅ and 200 mm long between reference marks. Minimum resilience by the Mesnager method.
...g/mm²	> 900 for R < 72 kg/mm² > 800 for R = 72-75 kg/mm² > 750 for R > 75 kg/mm²	< 40 kg/mm²	2-4 kgm/cm²	—	Coefficient of quality with test piece of 20 mm ∅ and 100 mm long.
	Steels fabricated under the indices « GOST » 8160-56, 4224-54, 6944-54, 5633-51				Test piece of 150 mm × 15 mm ∅ : M-76: B_t = 54.5 kg/mm², B_v = 95.0 kg/mm², B 10 = 8.0 kg/mm², fMM = 31.0 kg/mm² M-75: B_t = 56.0 kg/mm², B_v = 90.0 kg/mm², B 10 = 11.0 kg/mm², fMM = 37.0 kg/mm²
...kg/mm² ...kg/mm²		~ 60 kg/mm² 80-90 kg/mm²		70-80 kg/mm²	High resistance.
...kg/mm² ... head ...nd ...kg/mm² ... foot	13 in the head and 12.9 in the foot	30.2 kg/mm² in the head and 31.9 kg/mm² in the foot	—	138-148 normal on the running surface 190-244	The remaining specifications according to the U.S.T. railways regulations of the 23rd August 1951.
...kg/mm²	94	—	—	196	
...kg/mm²	< 104	—	—	< 200	Coefficient of quality with test piece of 20 mm ∅ and 100 mm long.

... of the tyres : C = 0.50-0.75
Mn = 0.41-1.20
Si = 0.15-0.50
P < 0.02-0.07
S < 0.02-0.07

... of the tyres : R = 75-105 kg/mm². For the other mechanical characteristics, no limits are given because many Administrations do not impose any.

TABLE 6. — **General data conce**

Ref. No.	Country	Administrations	*None of the Administrations use monobloc wheels on their electric locomo the steel used for rails and the tyres of locomotive wheels has not been al the characteristics : the former in 1930 by altering R = 70-80 kg/mn a special steel.*					
			Chemical analysis					
			C %	*Mn* %	*Si* %	*P* %	*S* %	*Remarks*
8	*HOLLAND*	*Netherlands Railways*	≤ 0.60	≤ 1.20	≤ 0.50	≤ 0.05	≤ 0.05	Oil hardened and temperin P + S ≤ 0.0 Nq ≤ 0.50 Va ≤ Cr ≤ 0.30 Mo ≤ 0.10 Cu ≤
9	*ITALY*	*Italian State Railways*	—	—	—	≤ 0.04	≤ 0.04	P + S ≤ 0.0
10	*ITALY*	*North Milan Railway*	—	—	—	≤ 0.04	≤ 0.04	≤ 0.07
11	*U.S.S.R.*	*U.S.S.R. Railways*	0.50-0.65	0.60-0.90	0.15-0.35	0.05	0.05	—
12	*SWITZERLAND*	*C.F.F.*	0.60	—	—	≤ 0.07	≤ 0.07	—
13	*SWITZERLAND*	*Rhaetian Railway*	—	—	—	—	—	UST standar of the 23 August
14	*TURKEY*	*Turkish State Railways*	—	—	—	—	—	Same materia as the Frenc National Railw See S.N.C.F.
15	*YUGOSLAVIA*	*Yugoslavian Railways*	—	—	—	≤ 0.05	≤ 0.05	P + S ≤ 0.0

The table shows that the chemical composition of steels used for rails varies between :

C = 0.37-0.82
Mn = 0.70-1.90
Si = 0.06-0.35
P ≤ 0.02-0.09
S ≤ 0.02-0.07

As regards the mechanical characteristics of these steels, those used for rails vary between :

R = 55-90 kg/

used for the rails and tyres *(continued)*.

ne Deutsche Bundesbahn which uses cast steel wheels on account of the special profile and running gear. The quality of compared with steam traction. Only in the case of the tyres have the C.F.F. (Switzerland) and F.S. (Italy) modified /mm², A = 13 % to A = 14 % and L = 10 d to L = 5 d (test pieces), and the latter by using on the fast light trains

ES

		Mechanical characteristics			
stance to aking ough ction	*Coefficient of quality*	*Apparent limit of elasticity to tension*	*Minimum resilience*	*Brinell hardness*	*Remarks* *R = tensile breaking load* *A = elongation at fracture %*
kg/mm²	115-127 kg/mm²	Not imposed	> 3 kgm/cm² (Charpy)	235-275 Difference between the numbers of a same cast < 30	For coefficient of quality test piece of 100 mm between reference marks and ∅ 20 mm. A > 16 %. Resilience test piece-card 810-1 U.I.C., depth of the notch 5 mm rounded off at *r* = 1 mm (I.S.A.).
kg/mm²	A = 14-11 %	Not laid down	4 kgm/cm² also 3 kgm/cm² for R = 80 kg/mm²	Not laid down	Coefficient of quality = R + 2.2 A. For resilience, Mesnager test piece.
kg/mm²	A = 11-14 %	40-50 kg/mm²	4 kgm/cm²	—	For coefficient of quality, test piece of 100 mm on 20 mm ∅. For resilience, test piece 1 × 1 cm with notch of 1 mm.
Steel fabricated under the indices « GOST » 398-41					Test piece taken from centre of tyre at 30 mm depth. *l* = 60 mm, ∅ = 15 mm. Bv = 75 kg/mm². *h* = 13 %. ψ = 16 %.
0 kg/mm²	St. C 60.61 treated	45 kg/mm²	—	—	—
2 kg/mm²	A = 12- 8 % for *l* = 5 *d* 10-7 % for *l* = 10 d	50 kg/mm²	3 kgm/cm²	222-262 kg/mm²	U.S.T. regulations of the 23rd August 1951 are used.
—	—	—	—	—	The regulations of the French National Railways are used. See S.N.C.F.
4 kg/mm²	$\sigma m + 2.2 \frac{8 \sigma m}{100}$	Not imposed	Not imposed	230-270	—

hat of the tyres : C = 0.50-0.75
Mn = 0.41-1.20
Si = 0.15-0.50
P < 0.02-0.07
S < 0.02-0.07

hat of the tyres : R = 75-105 kg/mm². For the other mechanical characteristics, no limits are given because many Administrations do not impose any.

2. Quality of the steels used for rails and tyres.

We have shown in this table the characteristics of the steels used for rails and the tyres of electric locomotive wheels. In general no modifications have been made to the characteristics of the steel used for these two components compared with those used in steam traction.

The only changes to report are those made by the C.F.F. and F.S. On the former, they have changed from steel with a resistance of 70/80 kg/mm² to steel of 80/92 kg/mm², the elongation being increased at the same time from 13 to 14. The latter are using a special steel for their light trains, but did not give the composition or category.

Mention must be made of the steel used for rails by the C.F.F.; its resistance to breaking by traction, 90 to 110 kg/mm² is the highest we have found from the figures given.

The same table also includes the coefficient of quality used by each Administration, with somewhat varied formulae. Some of them did not give any coefficients.

3. Wear of rails and tyres.

In the questionnaire sent to the different Administrations, we asked the average useful life of a rail with electric traction compared to steam traction. The information received did not give any precise replies to this question, because the Administrations did not know some of the facts needed to establish a definite comparison between the wear suffered by the rails with each method of traction. However, some of the Administrations supplied the following data :

Italy (State Railways).

The average life of a rail with electric traction is 20 years, whereas with steam traction it is 25 years. There is no doubt that this reduction in the useful life of a rail with electric traction is mainly due to the increase in the speed and the load both of the locomotive itself and that of the trains hauled when changing from one type of traction to the other.

U.S.S.R. Railways.

State that the lateral wear of the rail is five times greater with electric traction than with steam traction, and its vertical wear 30 % greater with the former than with the latter.

Austrian Railways.

Estimate at some 20 % the reduction in the life of rails on electrified lines.

4. Type and degree of wear which affect the useful life of rails.

In general, nearly all the Administrations report that the wear of the rail is conditioned by the wear of its ends, as well as by the greater or lesser number of curves. The need to replace them is shown in both cases by the apparition of flaws and cracks.

Some Administrations lay down limits for wear of rails, for example the Netherlands Rys. which fix the minimum height of the rail head at 20 mm and the maximum angle of inclination of the lateral wearing surface compared with the vertical axis of the section of rail at 32°.

The Bundesbahn estimates vertical wear of the rail at 0.05 mm per million tons.

5. Average mileage between two successive returnings of tyres.

As regards the average mileage between two turnings of tyres, *Table 7* gives the most important data. It is obvious that this mileage depends mainly on the type of locomotive used which, owing to its greater or lesser rigidity, has a varying effect upon tyre wear. For example, the Deutsche Bundesbahn fixes for its types E-04, E-18 and E-16 engines a mileage of 400 000 km, which is the highest of any given; on the other hand, for the type E-44 engines, this mileage falls to 175 000 km.

In Italy, likewise, the mileages are given

TABLE 7.

No.	*Country*	*Administrations*	*Average run between two turnings of the tyres.*
1	*WESTERN GERMANY*	*Deutsche Bundesbahn*	E 04, E 18, E 16 : 400 000 E 44 : 175 000 E 94 : 300 000
2	*ALGERIA*	*Algerian Railways*	100 000
3	*AUSTRIA*	*Austrian Railways*	80 000 — 300 000
4	*BELGIUM*	*Belgian National Railways*	Railcars : 175 000-225 000 Loc. 122 : 300 000 » 101 : 225 000
5	*BELGIUM (Colony)*	*Lower Congo to Katanga Railway*	120 000
6	*SPAIN*	*R.E.N.F.E.*	80 000 — 150 000
7	*FRANCE*	*French National Railways*	200 000
8	*HOLLAND*	*Netherlands Railways*	175 000
9	*ITALY*	*Italian State Railways*	Loc. E.626-636 : 225 000 » E.624 : 165 000 » E.428 : 325 000
10	*ITALY*	*North Milan Railway*	100 000 — 120 000
11	*U.S.S.R.*	*U.S.S.R. Railways*	200 000
12	*SWITZERLAND*	*C.F.F.*	200 000 — 300 000
13	*SWITZERLAND*	*Rhaetian Railway*	200 000 (2 years)
15	*YUGOSLAVIA*	*Yugoslavian Railways*	100 000 — 150 000

as a function of the type of locomotives: they vary between 165 000 and 325 000 km.

In general, the mileage is between 100 000 and 200 000 km, and depends, as is natural, on the greater or lesser hardness of the profiles in the case of curves of small radius.

6. Immobilisation of locomotives on account of tyres being returned.

Once there is wear of the tyres on locomotives, nearly all the Administrations find it necessary to immobilise them for a more or less long period in order to turn the tyres, not only because they have reached the limit of wear laid down for each type, but because the formation of flats and exfoliations in their turn affect the profile which then has to be corrected. It is obvious moreover that since the locomotives have to undergo periodic overhauls to inspect and adjust certain mechanical and electrical components, profit is taken to undertake certain turnings of tyres, which thus reduces the amount of complete immobilisation of

the motor stock for turnings. There are some Administrations, however, for example the Lower Congo Railways, where no such immobilisation is necessary, since they have a sufficient number of spare bogies.

7. General form taken by tyre wear.

The running surface and that of the flange are the places where wear occurs most rapidly, depending upon the nature of the layout of the line (proportion of straight sections and curves). The wear of the running surface is greater than that of the flanges when the proportion of straight sections is higher than the curves. In this case it is only necessary to retread the running surface and slightly touch up the flanges.

If there are a great many curves on the line compared with straight sections, the wear of the flange is greater than that of the running surface. In this case, it is necessary to return the tyre in order to restore the profile of the flange, without the touching up required in the previous case.

8. Maximum wear authorised for the running surface and the flanges.

In general, the limits vary according to the characteristics of the lines. If there are many curves and the locomotive has a large rigid wheelbase, the greater speed with which the flange wears means there will not be much wear of the running surface before it is necessary to return the tyres; the contrary occurs when the straight sections predominate.

The maximum wear of the running surface is usually fixed at 5 mm. On certain Administrations, like the R.E.N.F.E. and Algerian Railways, this wear is limited to 3 mm.

On the other hand, the wear of the flange is mainly limited by the need to keep it above a minimum thickness. The limits for this vary between 20 and 25 mm. Certain Administrations also fix the height at which this thickness must be measured; this is generally 10 mm from the running surface. Naturally less wear is allowed in the case of locomotives running at speeds of more than 100 km/h.

Table 8 shows the maximum wear allowed for running surfaces and flanges.

9. Differences in wear on different axles of the locomotives.

On locomotives with 3 or 4 axled bogies, there is always much greater and faster wear of the tyres on the outer axles than on the inner axles.

This difference in the wear on different axles is fairly considerable. The Netherlands Railways report that the wear of the flanges of the inner axles is approximately only half that on the outer axles of the locomotive. On the other hand, on the B-B or B-B-B locomotives there is no appreciable difference in wear on the different axles.

10. Effects of returning the tyres and the resultant reduction in their diameter upon their faster wear compared with new tyres.

It does not seem to have been proved that multiple returnings have any effect on the speed with which wear occurs. It can therefore be affirmed that in general the mileage between two returnings is in practice independent of previous returnings.

11. Influence of various factors on tyre wear.

a) *Value imposed by the ratio* $\frac{P}{D}$ (P *being the total axle load and* D *the diameter of the wheels). Maximum value authorised at the present time and maximum expected in the future.*

Most of the Administrations do not fix any predetermined value for the ratio $\frac{P}{D}$ when designing new electric locomotives.

However, the S.N.C.F. makes the reservation, that though it does not impose such a value, the following figures have been fixed as the maximum for this ratio in the case of the modern locomotives :

	Metric tons and metres	English tons and feet
CC express with completely suspended motors . .	14	4.3
BB mixed with nose suspended motors	16	4.9
CC freight, with semi-suspended motors . . .	19	5.7

The Netherlands Rys. stipulate $P < 0.016\,D$ in tons and metres and the Jugoslavian Rys.

$$\frac{P}{D} = \frac{20 \text{ t.}}{1\,250 \text{ mm}}$$

b) *Peripherical speed of the wheels.*

No relation appears to have been noticed between the peripherical speed of the wheels and the wear of the tyres.

c) *Types of bogies used and connections between bogies.*

It was not possible to get any sufficiently clear opinion as to the possible influence of the types of bogies used by the different Administrations upon the wear of the tyres.

Certain Administrations, such as the Italian State Rys., the Swiss Federal Rys., the Austrian Rys., and the R.E.N.F.E. report that there is a definite relation between the wear of the running surface and the flange and the type of connection between bogies. In fact, the last Administration has observed considerably reduced wear of the flanges on the outer axles of certain types of the C-C locomotives when there is an elastic connection between the inner headstocks. In the same way the S.N.C.F. reports that this influence begins to be appreciable when the recall force is of the order of 10 tons.

d) *Undulatory wear of the rails.*

None of the Administrations consulted was able to give any figures concerning this influence, not having carried out any researches in this connection.

e) *Type of suspension of the motor.*

Although at first sight it would seem logical to suppose that completely suspended motors should have a beneficial effect upon the wear of the tyres, it has not been possible so far to establish any relationship between the type of suspension of the motors and the wear in question, for the same reason as in the previous case.

f) *Services worked.*

As most of the modern electric locomotives are of the so-called « universal » type, i.e. designed for use on both passenger and freight trains, thus assuring a mixed service, the Administrations find it impossible to determine whether the kind of service worked, from the point of view of the speed by express trains, stopping and freight trains has any influence upon the wear of the tyres.

Only the S.N.C.F. state that there is a certain relation between the wear of the tyres and the kind of service. For two comparable series of locomotives, each used on a different service, the wear of the tyres is about 10 % less on locomotives working fast services than on those used for the mixed services.

g) *Use of automatic rail lubricators.*

To reduce the wear of the tyres, especially that of the flanges, many Administrations have used automatic rail lubricators. The Deutsche Bundesbahn, Lower Congo to Katanga Railways, R.E.N.F.E., C.F.F., Rhaetian Ry. and Jugoslavian Rys. do not make use of them.

TABLE 8.

No.	*Country*	*Administrations*	*Running surface*	*Flange*	*Remarks*
1	*WESTERN GERMANY*	*Deutsche Bundesbahn*	7.5	7	Lateral wear of the wheel flange.
2	*ALGERIA*	*Algerian Railways*	3	1/3	Relative to the thickness of the flange.
3	*AUSTRIA*	*Austrian Railways*	7.75	7	—
4	*BELGIUM*	*Belgian National Railways*	5	11	Wear of the flange in height-thickness 20 mm.
5	*BELGIUM (Colony)*	*Lower Congo to Katanga Railway*	5	—	Minimum thickness of the flange = 20 mm.
6	*SPAIN*	*R.E.N.F.E.*	3	7	The wheel tread is reduced to 30 mm at the last turning of the tyres.
7	*FRANCE*	*French National Railways*	5	—	Max. height of the flange = 36 mm. Minimum thickness of the flange = 25 mm
8	*HOLLAND*	*Netherlands Railways*	—	5	Thickness of the wear of the flange. Min. thickness of the tyre = 45 mm.
9	*ITALY*	*Italian State Railways*	—	—	Min. thickness of the flange = 22 mm. Max. height = 36 mm.
10	*ITALY*	*North Milan Railways*	—	—	Min. thickness of flange = 22 mm.
11	*U.S.S.R.*	*U.S.S.R. Railways*	7	—	—
12	*SWITZERLAND*	*C.F.F.*	9	—	Min. thickness of the flange = 25 mm. Max. height = 36 mm.
13	*SWITZERLAND*	*Rhaetion Railway*	11	—	Min. thickness of flange = 20 mm.
14	*TURQUEY*	*Turkish State Railways*	—	—	—
15	*YUGOSLAVIA*	*Yugoslavian Railways*	—	8	—

These lubricators are mainly used on curves of small radius, for example 300 to 500 m, and sometimes by points; however the Belgian Rys. also use rail lubricators on curves of 1 200 m, in general siting them at the beginning of the curve. One Administration only (the Algerian Rys.) states that the lubricators in question are fixed at the spot where the superelevation reaches 40 mm.

Various types are used. In fact :

The S.N.C.B. uses a single type, consisting of a cylindrical reservoir fixed outside the rail containing grease graphited under pressure. This escapes over the lateral inside face of the railhead under the action of two pistons worked as each tyre passes over them. The grease used has been perfected by the firm of CALTEX.

The Algerian Rys. use automatic rail lubricators, P & M type. The lubricant used is 50 G graphited grease (ESSO-Standard).

The Italian State Rys. use two types of lubricators, which are now under trial, in the form of equipment fastened to the rails or placed on the locomotives. The grease used is a mixture of calcareous soap and mineral oil, saponifiable oil and graphite, in the following proportions :

Saponifiable oil . .	not more than 3 %.
Lime soap . . .	10 to 14 %.
Acids	not more than 0,2 %.
Water	not more than 2 %
Graphite	12 to 14 %.
Ash	not more than 12 %.
Penetration by ASTM method of grease used at 25° C : . . .	305/335.
Ubbelhode drip point.	above 85°.

The Netherlands Rys. use the English P & M type.

The S.N.C.F. generally lubricate the rails by means of mobile lubricators fitted on the locomotives. However, in certain cases, for example on isolated curves of lines with fairly heavy traffic, P & M type lubricators are used (pumps driven by small fingers worked by the passage of the wheel which lubricate the rail) fitted outside the track; the hollow spindles form a sort of tube which brings the oil used as lubricant over the inside surface of the railhead. Although these lubricators are placed at the entry to curves, they must be carefully sited if good results are to be obtained. If there are a relatively large number of curves, it is more economical to use lubricators fitted on the engines.

The Rhaetian Ry., in addition to greasing the flanges by lubricators fitted on the locomotives, also has the inside surface of the railhead greased occasionally by the platelayers equipped with a manual lubricator mounted on a small truck. The lubricant used is old oil, or a special grease (Aseol) with a graphite base.

As regards the economic advantages of using rail lubricators, all the Administrations which have used them report considerable reduction in the lateral wear of the rail, and some, like the S.N.C.B. and Algerian Rys., report an increase in the life of the rail of 100 % and 50 % respectively.

The S.N.C.F. calculates that on certain twisting lines, the mileage before the locomotive tyres have to be returned can be increased threefold or even fourfold.

h) *Use of flange lubricators.*

Flange lubricators have become generally used on electric locomotives; they are fitted on all the axles, or only on the guiding axles.

There are a great many types of flange lubricators; mention may be made of those known under the names of LUBROVIA, BERTSCHMANN, LIMONFLUHME, FRIEDMANN, and those consisting of electro-graphited carbon rods, oil pulverisators by means of ejectors worked by compressed air, etc.

All the Administrations agree in affirming that the use of flange lubricators gives positive economic advantages, without being able to estimate these in any precise fashion.

The principle on which the LUBROVIA lubricators are based makes it possible to use them either on the wheels or on the

TABLE 9.

No.	Country	Administrations	Lubricants
1	*GERMANY*	*Deutsche Bundesbahn*	Solid grease resisting to frost and water.
2	*ALGERIA*	*Algerian Railways*	Recovery oil.
3	*AUSTRIA*	*Austrian Railways*	Unclean bearing oil (Vulkan).
4	*BELGIUM*	*Belgian National Railways*	Bisulphide of molybdenum (test).
5	*BELGIUM (Colony)*	*Lower Congo to Katanga Railways*	Electro-graphitic and paraffined carbon.
6	*SPAIN*	*R.E.N.F.E.*	H. 7. recovery oil.
7	*FRANCE*	*French National Railways*	M (1) oil and from recovery, petroleum or gasoil added in cold weather.
12	*SWITZERLAND*	*C.F.F.*	Graphite in loaves. De Limón grease Shell. Tonni, grease-graphite-oil mixed. DI. Laussanne oil.
13	*SWITZERLAND*	*Rhaetian Railway*	Waste oil.

rail. This type, mainly used by the S.N.C.F., has the advantage, when it is lubricating the rail, that its use is good both for the motor stock and hauled stock.

As regards the lubricants used, we have collected the data received in *Table 9*.

12. Methods of repairing tyres.

a) *Turning.*

In general, for turning tyres ordinary tools and forming-tools are used, the latter in particular for the flange in the final phase.

The steel used for the tools is of the ordinary or hard kind.

The lathes used can be hand lathes or forming lathes.

One Administration removes the burr which occurs at the highest part of the flange by grinding.

Neither formed milling cutters nor grinding wheels are used for turning the tyres, the only case to be reported being the special case mentioned above.

b) *Welding.*

Building up the tyres by welding is not yet the general practice.

One Administration, the Algerian Rys., uses the Union-Melt system with a welding current of 70 V, 650 A.

The Italian State Rys. begin by heating the surface which is to be built up to 250 or 300° using D.C. and basic electrodes, taking care that cooling takes place as slowly as possible, thanks to an asbestos protective plate.

Finally the R.E.N.F.E. merely builds up the flanges, seeing that these undergo the most wear, owing to the many small radius curves its locomotives have to run through.

these bearings	
	Woven

The other Administrations consulted stated that they do not use the method of building up tyres by welding.

As for the economic advantages obtained, it appears that there is an appreciable saving in the tyre material, the period between overhauls being increased by 30 to 50 % according to the information supplied respectively by the U.S.S.R. Railways and C.F.F. Rys.

c) *Turning the tyres without having to remove the axles concerned from the locomotive.*

Except for the U.S.S.R. Railways, the other Administrations remove the axles from the locomotives to turn the tyres. They are all trying to find some method enabling this turning to be done without removing the axles from the engine, but up to the present have not found any satisfactory solution.

For their part the U.S.S.R. Railways stated that they have adopted a system of tyre turning which makes it possible to carry out this operation without having to remove the axles from the electric locomotives, but they give no details of the device used. On the other hand, with other types of locomotives, they have not yet adopted turning « in situ ».

III.

III. METHODS USED FOR MAINTAINING THE TRACTION MOTORS AND DRIVE.

1. General information concerning the traction motors currently used.

Table 10 gives a brief description of the traction motors used by the different Administrations we consulted, as regards the number of main and auxiliary poles, number of brush lines, number of brushes per line, number of commutator segments, etc.

2. Brushes and brush-holders.

According to the information received, fixed or adjustable brushes are used without distinction, both of the interchangeable type.

The modern S.N.C.F. motors are generally fitted with adjustable holders which, according to this Administration, are easier to maintain.

The majority of Administrations do not use any special device in the brush-holders to reduce the damage caused by flash over the commutator. However, some of them, such as the S.N.C.F., F.S., Austrian Federal Railways and Jugoslavian Railways use spark gaps, screens or pairs of points one of which is connected to earth.

As for the types of brushes, monobloc or divided brushes are used without distinction. On modern motors there is a tendency to use the latter type.

Finally, as regards the type of connection, flexible connections are often used, formed of a copper band of large section acting as shunt between the brush and the brush-holder, as well as rigid connections (Ringsdorf, Giambonini, pressure cams, and other types).

3. Transmissions.

We have collected together in *Table 11* a summary of the data received concerning the transmissions. This shows, in addition to the Administration, the series or type of locomotive, unilateral or bilateral drive, rigid or elastic gears, type of gearing, and the lubricant currently used, as well as the type of gearbox and type of joint.

4. Maintenance and repair of traction motors.

The Administrations do not all make daily inspections of the traction motors. When this takes place, this inspection is made together by the inspector and locomotive driver. On the other hand, overhauls are made every fortnight or month, which corresponds to a mileage of between 12 000 and 15 000 km.

TABLE 11. — **General** [...]

Ref. No.	Country	Administrations	Series or type of locomotive	Data concern[...]	
				Unilateral or bilateral	*Rigid or elastic gears*
1	*WESTERN GERMANY*	*Deutsche Bundesbahn*	—	Unilateral and bilateral	With springs for rigid transmission Without spring[s] for nose-suspension an[d] elastic drive by helical springs
2	*ALGERIA*	*Algerian Railways*	CC 5 AE BB 4 AF	— Bilateral	Rigid Elastic
3	*AUSTRIA*	*Austrian Railways*	—	Unilateral and bilateral	Elastic
4	*BELGIUM*	*Belgian National Railways*	101 120 121 122 123	Bilateral Unilateral BBC elastic disc Unilateral »	Elastic Rigid » Elastic »
5	*BELGIUM (Colony)*	*Lower Congo Railway*	2 100 2 200	Unilateral Secheron Unilateral	Rigid Elastic
6	*SPAIN*	*R.E.N.F.E.*	1 000 1 100 6 000 6 100 7 000 7 100 7 200 7 300 7 400 7 500 7 600 7 700 7 800	Unilateral » » » » » Bilateral Central Unilateral Bilateral Unilateral » »	Rigid » » » » » Elastic » Rigid Elastic » Rigid »

; the transmission.

smission		
ight teeth or other	*Lubricants used*	*Type of gearbox and type of joint*
)rive : al : straight al : oblique	Viscous oil (steam cylinder oil)	Studded covers and cast clamps.
:raight	Pebron grease Motor oil	Moreau joint. Felt joint.
and oblique	Oil (superheated cylinder oil)	Protective cases in sheet and cast carcases.
raight » » » »	Shell S 1 683 JET TM Sinclair Gargoyl Compound 6 JET TM Sinclair » » »	Welded sheets. Boxed in joints. » » » Grooved welded sheet. Adjustable joint. Welded sheet. Boxed in joint. » » »
lélinée raight	High viscosity oil » » »	Sheet. Leather and synthetic rubber joints. » » » »
raight » » blique raight » » blique raight » » » »	Grease ligosa CAMPSA » » » » » » » » » S A.E. 60, S.A.E. 40 and D. 26 S.A.E. 60 and S.A.E. 40 CAMPSA S.A.E. 40 S.A.E. 40 CAMPSA H 7 CAMPSA S.A.E. 40 72-12 Compound D, Corbula D Shell Corbula C » » »	Sheet. Leather joint. » » » Cast. No joint. Sheet. No joint. Sheet. Felt joint. » » » Cast. Leather joint. » » » Sheet. Leather joint. Casr. Leather joint. Cast. Sheet. Felt joint. Sheet. Cork joint.

TABLE 11. — General

Ref. No.	*Country*	*Administrations*	*Series or type of locomotive*	*Data conce*	
				Unilateral or bilateral	*Rigid or elastic gears*
7	*FRANCE*	*French National Railways*	BB (101-180)	Unilateral	Elastic
			BB (301-324)	Bilateral	»
			BB (325-355)	»	»
			BB (901-935)	»	Rigid
			BB (4101-4177, 4201-4250, 4580-4699 and 4701-4721)	»	»
			2 D 2 (5001-5024)	»	»
			2 D 2 (5105-5120)	»	»
			2 D 2 (5302-5306)	»	Elastic
			2 D 2 (5401-5423 and 5503-5550)	»	»
			CC (7101-7143)	»	»
			CC (7144-7158)	»	Rigid
			BB (8101-8271)	»	Elastic
			BB (9001-9002)	Unilateral	Rigid
			BB (9003-9004)	Bilateral	Elastic
			2 D 2 (9101-9135)	»	»
			BB 10001	Unilateral	»
			BB (12001-12113)	Bilateral	»
			BB (13001-13053)	»	»
			CC (14001-14020)	Unilateral	»
			CC (14101-14202)	»	»
			CC (20001 and 25001-25009)	»	»
8	*HOLLAND*	*Netherlands Railways*	1000	Central universal S.L.M. Winterthur	
			1100 and 1300	Bilateral	Swing bushes
			1200	Unilateral	Rigid
9	*ITALY*	*State Railways*	—	Unilateral	Rigid
10	*ITALY*	*North Milan Railways*	—	Unilateral and opposed on each axle of each bogie	Rigid
11	*U.S.S.R.*	*U.S.S.R. Railways*	—	Bilateral	—
12	*SWITZERLAND*	*C.F.F.*	—	Unilateral bilateral rods	Elastic
13	*SWITZERLAND*	*Rhaetian Railway*	1 D 1	Bilateral	Rigid
			CC	»	Elastic pinio
			Bo Bo	Unilateral	Elastic (BBC
15	*YUGOSLAVIA*	*Yugoslavian Railways*	—	Unilateral	Rigid

g the **transmission** *(continued)*

smission		
ight teeth or other	*Lubricants used*	*Type of gearbox and type of joint*
Straight	Oil TE	Semi-suspended. Felt joint.
»	» »	» Leather boxed in joint.
»	» »	» » » » »
»	» TR	» Felt joint.
»	» »	» » »
»	» »	Entirely suspended. White hard felt joint.
»	» »	» » Hard felt joint.
»	» TE	» » » » »
»	» M	» » Joint 5400: presspan; 5500: joinfronite.
»	» TE	» » Leather joint.
»	» »	» » » »
»	» »	Semi-suspended. Leather joint.
»	» M	» No joint (outlet groove).
»	» TE	Entirely suspended. Felt joint.
»	» M	» » Joinfronite joint.
»	» TE	Semi-suspended. Leather joint.
»	» »	Entirely suspended. Rubber and felt joint.
»	» »	» » » » » »
»	» »	Semi-suspended. Asbestos and felt joint.
»	Shell Spirox 90 EP oil	» Villumoïd joint (1) and felt.
Helical	Oil M	Entirely suspended. No joint (outlet groove).
Oblique	Valvata 1.78	Silumin cast iron. Leather joints and rubber rings.
Straight	Compound nº 7	Sheet steels. Joints and rings of felt and leather.
»	Mytilus A	» » » » » » » and with labyrinth.
Straight	Gear grease (winter and summer type)	Sheet. Labyrinth joint.
Straight	Viscolite	Standard box. No joint.
t and oblique	Transmission oil	Sheet steel.
t and oblique	Standard oil	Welded sheet steel. Rubber joint.
Straight	Grease	Multiple sheet box.
Oblique	»	» » »
»	Oil	Two piece box in sheet.
Straight	Blend of bitume, cylinder oil and celophane	Sheet in two parts with reinforcing ribs.

(1) Glycerin plastified cellulose.

In general, the name of « periodic inspection » is given to that which takes place every 3 or 4 months, corresponding to mileages of 20 000 to 50 000 km; « intermediate overhauls » to those which take place every 100 000 or 120 000 km, and « general overhaul » that which corresponds to a mileage of the order of 240 000 to 600 000 km.

Description of work done at each of these overhauls.

i) The daily inspection is usually a simple examination, without any repairs.

ii) In the case of the inspections carried out every fortnight, the brushes, springs, brush-holders and insulators are examined. If necessary, the resistance of the insulation is measured and worn brushes are replaced.

iii) During the periodic inspections « in addition to examining the condition of the collectors, the important parts of the armature and connections are examined, and the interior of the motors is blown out and cleaned.

iv) Finally, during the general inspections or overhauls, the motors are disconnected, the bearings, induction coils and armature cleaned; a general check-up is made of the lubrification, the commutator is rectified on the lathe if necessary, the brush-holders checked and rectified, and finally, if considered necessary, complete or partial rewinding is carried out. In this case, it is considered essential to test the motor on no load.

The frequency with which the commutators are turned varies according to the Administrations, depending to whether this is based on years in service or on mileage run. In the first case, the frequency varies between 1 and 3 years; in the second, between 200 000 and 600 000 km; exceptionally, it is as much as 1 200 000 km on the C.F.F.

The S.N.C.F. fix as limits 400 000 to 600 000 km with D.C. and stipulate that this limit should be above 600 000 km in the case of A.C. single phase, industrial frequency motors.

We asked the Administrations if, before turning the commutator, the wear of the latter was measured. In general, the wear is noted as far as markings left upon the commutator by the rubbing of the brushes are concerned. Their depth determines in many cases whether turning is necessary. In other cases, the ovalisation of the commutator is checked, and it is precisely the measurement of this latter which is taken as the basis in determining the advisability of turning during the periodic repairs, as is the case for example on the Italian State Railways. The rest of the Administrations merely note the wear.

In the case of motors recently put into service, the S.N.C.F. check these measurements systematically and prepare a small graph on which the ovalisation of the commutator is recorded, which serves as basis for the comparative study of the way it stands up in service.

Obviously, all these operations to the motors are done during the immobilisation of the locomotive for the inspection and overhaul of other parts, for example turning the tyres or overhauling the mechanical part.

One of the immobilisations of locomotives being due to the need to turn the tyres, such immobilisations are used to carry out when necessary, certain of the above mentioned operations on the traction motors, but in general there is no coincidence between the work of inspecting and repairing the motors and the turning of the tyres, which usually is necessary after a smaller mileage than that after which the general repair of the motors is necessary. In many cases, such immobilisations of the locomotive are used solely to blow out the armatures with compressed air.

5. Checking the pressure of the brush on the commutator.

The pressure of the brush on the commutator is very variable and depends on the type of motor, the characteristics of the latter and the nature of the service for which it is used. Thus, for example, it is

seen that the pressure varies between 220 and 560 g/cm²; it is currently determined by means of a dynamometer or spring balance.

6. Dimensions of the brush and brush-holder.

Table 12 sums up all the data concerning these two components, giving for each Administration the dimensions and tolerances for the carbon brushes and brush-holders, according to the different types of engines used; it is easy to understand that these figures show a great deal of variation and depend upon the type of motor.

7. Taking a motor out of service on account of damage to the commutator.

It is very rare that damage to the commutator makes it necessary to take the motor out of service. However, in order to reduce this risk to the minimum, the commutator should be cleaned during the periodic overhauls, thus avoiding deposits of dust; as well as when examining and improving the functioning of the brush-holder and checking that the commutator and armature are co-axial.

8. Use of modern types of insulating, with a silicone or other basis.

In the construction and repairing of traction motors, so far the classic types of insulating have been used. Only the Deutsche Bundesbahn has used insulants of the modern type in conformity with its technical development to reduce possible damage. In the same way the S.N.C.F. is now studying the possibility of using them on old motors in order to prolong their life.

9. Cracks in the shafts of the motors.

When overhauling the motors, cracks are sometimes found in the shaft, which could lead to damage of considerable extent. We asked the Administrations if the construction of the motors made it possible to remove the shaft without dismantling the armature, in order to make it easier to detect cracks. In many cases, this operation can be done quite easily, but not in all. In designing new types of motors, the possibility of removing the shaft easily from the rest of the armature should be borne in mind, in order to detect cracks in time to prevent more serious damage occurring to the armature.

From the information we received, it appears that the formation of cracks in the shafts of the motors is not a frequent matter and this is why many Administrations have not provided any means for detecting such cracks. Those who do carry out such investigations generally use the ultrasonic method, or a magnetoscopic method, or use a magnetic defectoscope (S.N.C.F.) and a magnetic metaloscope (North-Milan).

In view of the fact that such cracks rarely occur, as we have already said, in general it has not been laid down at what intervals this operation shall be carried out, except on the Netherlands Railways which have fixed it at 400 000 km and the Lower Congo (120 000 km). Other Administrations carry it out whenever repairs have to be made, so that the armature shaft is accessible when a bearing gets hot.

10. Armature bearings.

a) *Dismantling and replacing the armature bearings.*

To inspect and if necessary replace the armature bearings, use is made of the general overhauls to the locomotive. On the average it can be stated that the periodicity varies, according to the administration, from 200 000 to 800 000 km.

In the case of completely suspended motors, the S.N.C.F. varies this periodicity between 600 000 and 1 200 000 km.

b) *Constitution of the motor shaft bearings.*

TABLE 12. — **Dimensions and tolerances for brushes and brush holders.**

WESTERN GERMANY			*ALGERIA*	*AUSTRIA*
DEUTSCHE BUNDESBAHN			*ALGERIAN RAILWAYS*	*AUSTRIAN RAILWAYS*
Locomotive series or type				
E. 04 and 18	E. 16	E. 44 and 94		
$40 \times 10 \times 50$ (Double carbon) 2×5 mm)	$40 \times 16 \times 50$ (Triple carbon) 3×5.33 mm)	$45 \times 10 \times 50$	Carbon brushes : $L = 50^{+0}_{-0}$ $C = 16^{+0.025}_{-0.025}$ Holder : $L = 100.4^{+0.1}_{-0}$ $C = 16.03^{+0.1}_{-0}$ (with two brushes of 0.50).	Width of the carbons : 10, 11, 12.5, 14 and 16 mm. Mainly widths of 10 and 12.5 mm. The length varies between 45 and 50 mm. Height : 50 mm. On old motors up to 65 mm. Tolerances for carbons and brush holders. Austrian standard specifications E. 4 861. For the holders : Width 8-10 mm $\left\{\begin{matrix}+0.06\\+0.00\end{matrix}\right.$ No tolerances for the lengths. Width 12.5 mm $\left\{\begin{matrix}+0.07\\+0.00\end{matrix}\right.$ lengths $\left\{\begin{matrix}+0.11\\+0.00\end{matrix}\right.$ Width 14 mm not laid down. Width 16 mm $\left\{\begin{matrix}+0.11\\+0.00\end{matrix}\right.$ lengths $\left\{\begin{matrix}+0.11\\+0.00\end{matrix}\right.$ For the carbons : Width 8-10 mm $\left\{\begin{matrix}-0.04\\-0.13\end{matrix}\right.$ Width 12.5 mm $\left\{\begin{matrix}-0.05\\-0.16\end{matrix}\right.$ Width 14 mm not laid down. Width 16 mm $\left\{\begin{matrix}-0.05\\-0.16\end{matrix}\right.$ On the new motors, grooved carbons, width half the above figures.
« Dimensions and tolerances of carbon brushes for traction motors » DIN 43 020 sheets 1 and 2.				

TABLE 12. — **Dimensions and tolerances for brushes and brush holders** *(continued)*.

BELGIUM				
BELGIAN NATIONAL RAILWAYS				
Locomotive series or type				
	101	*120*	*121*	*122 et 123*
sh :	60 × 40 × 20	60 × 40 × (25/2)	55 × 40 × 30	60 × 40 × (25/2)
sh holder :	2 × 40 × 20	(2 × 40) × 25	40 × 30	(2 × 40) × 25

ximum play allowed : 0.6 mm in thickness and 0.8 in width.

ndardisation of the tolerances for locomotives is in hand.

Brushes : width $\begin{cases} +0.0 \\ -0.1 \end{cases}$ thickness $\begin{cases} +0.0 \\ -0.1 \end{cases}$

Brush holders : width $\begin{cases} +0.5 \\ -0.25 \end{cases}$ thickness $\begin{cases} +0.20 \\ -0.10 \end{cases}$

LOWER CONGO RAILWAY		
Type	Holder	Brush
M N 93	$10^{+0.25}_{+0.15} \times 121\text{-}0.5$	$10^{\pm 0.05} \times 60\text{-}0.25$
2 M S 51	$10^{+0.25}_{+0.15} \times 111\text{-}0{\cdot}5$ $10^{+0.25}_{+0.15} \times 55^{+0.5}_{-0.25}$	$10^{\pm 0.05} \times 55\text{-}0.25$

TABLE 12. — **Dimensions and tolerances for brushes and brush holders** *(continued).*

SPAIN

R.E.N.F.E.

Locomotive series or type

	1 000	1 100	6 000	6 100	7 000 et 7 100	7 200 et 7 500
Brush . . .	63.5 × 50.8 × 15.87	63.5 × 47.6 × 22.2	57 × 57.1 × 15.87	63.5 × 44.44 × 12.7	60 × 50 × 20	55 × 50 × 25.05
Brush holder	—	—	—	—	—	25.1 min. / 25.15 max. × 50.5

	7 300	7 400	7 600	7 700	7 800
Brush . . .	60 × 50.5 × 25	60 × 44 × 25	$55 \times 38^{+0.0}_{-0.25} \times 15^{+0.0}_{-0.05}$	53.97 × 38 × 14.27	58 × 44 × 7.9
Brush holder	—	21.5 × 44.2	$38^{+0.4}_{-0.2} \times 13^{+0.10}_{+0.05}$	—	—

For the play allowed in the case of new brushes in the brush holder limits fixed at 0.1 to 0.25 mm. In the case of play below the lower limit, the brush may stick to the holder, and with greater play than the upper limit, it may disintegrate or break owing to excessive vibration. The brushes have to be renewed when the play amounts to 0.05 mm.

FRANCE

FRENCH NATIONAL RAILWAYS

Locomotive series or type

	BB (101-180)	*BB (301-355)*	*BB (901-935)*	*BB (4101-4177) (4201-250) - BB (4 580-699) (4 701-721)*
Brush	$50^{-0.0}_{-0.15} \times 15^{-0.0}_{-0.08}$	$44^{-0.0}_{-0.25} \times 18^{-0.0}_{-0.1}$	$45^{-0.0}_{-0.15} \times 18^{-0.0}_{-0.08}$	$45^{-0.0}_{-0.2} \times 16^{-0.0}_{-0.1}$
Brush holder .	$50^{+0.15}_{+0.05} \times 15^{+0.1}_{+0.05}$	$44^{+0.4}_{-0.2} \times 18^{+0.1}_{-0.05}$	$45^{+0.18}_{+0.08} \times 18^{+0.09}_{+0.05}$	$45^{+0.15}_{+0.05} \times 16^{+0.1}_{+0.05}$

TABLE 12. — **Dimensions and tolerances for brushes and brush holders** *(continued).*
FRANCE (S.N.C.F.) (continued).

	2 D 2 (5001-5024)	*2 D 2 (5105-5120)*	*2 D 2 (5301-5306)*	*2 D 2 (5401-5423)* *2 D2 (5503-5550)*
h	$40^{-0.0}_{-0.15} \times 18^{-0.0}_{-0.08}$	$38^{+0.0}_{-0.25} \times 20^{+0.0}_{-0.1}$	$38^{-0.0}_{-0.25} \times 23^{-0.0}_{-0.1}$	$35^{-0.0}_{-0.15} \times 30^{-0.00}_{-0.08}$
h holder .	$40^{+0.15}_{-0.05} \times 18^{+0.1}_{+0.05}$	$76^{+0.3}_{+0.1} \times 20^{+0.1}_{+0.05}$	$38^{+0.5}_{+0.2} \times 23^{-0.0}_{-0.05}$	$35^{+0.15}_{+0.05} \times 30^{+0.1}_{+0.05}$

	CC (7101-7143)	*CC (7144-7158)*	*BB (8101-8271)*	*BB (9001-9002)*
h	$42^{-0.0}_{-0.25} \times 10^{-0.0}_{-0.05}$	$42^{-0.0}_{-0.35} \times 8^{-0.0}_{-0.05}$	$42^{-0.0}_{-0.25} \times 10^{-0.0}_{-0.05}$	$35^{-0.0}_{-0.1} \times 30^{-0.0}_{-0.1}$
h holder .	$42^{+0.4}_{+0.2} \times 20^{+0.1}_{+0.05}$	$42^{+0.4}_{+0.2} \times 16^{+0.1}_{+0.05}$	$42^{+0.4}_{+0.2} \times 20^{+0.1}_{+0.05}$	$35^{+0.3}_{+0.1} \times 30^{+0.15}_{+0.1}$

	BB 9003	*BB 9004*	*2 D 2 (9101-9135)*	*BB 10001*
h	$50^{-0.0}_{-0.2} \times 10^{-0.0}_{-0.05}$	$38^{-0.0}_{-0.25} \times 11.5^{-0.0}_{-0.0}$	$35^{-0.0}_{-0.2} \times 30^{-0.0}_{-0.1}$	$42^{-0.0}_{-0.35} \times 8^{-0.0}_{-0.05}$
h holder .	$50^{+0.02}_{-0.0} \times 20.1 \pm 0.02$	1from$38.05^{+0.15}_{-0.0} \times 23^{+0.05}_{+0.02}$ 1 from $76.1^{+0.15}_{-0.0} \times 23^{+0.05}_{+0.02}$	$35^{+0.15}_{+0.05} \times 30^{+0.1}_{+0.05}$	$42^{+0.4}_{+0.2} \times 16^{+0.1}_{+0.05}$

	BB (12001-12135)	*BB (13001-13053)*	*CC (14101-14202)*	*CC (20001 et 25001-25009)*
h	$45^{-0.0}_{-0.25} \times 10^{-0.0}_{-0.05}$	$55^{-0.0}_{-0.2} \times 4.37^{-0.0}_{-0.05}$	$42^{-0.0}_{-0.25} \times 8.5^{-0.0}_{-0.05}$	$50^{-0.0}_{-0.2} \times 5^{-0.0}_{-0.05}$
h holder .	$135.15^{+0.15}_{-0.0} \times 20^{+0.05}_{+0.02}$	2 from $110^{+0.26}_{-0.12} \times 8.8^{+0.1}_{-0.04}$ 1 from 55 $\times 8.8^{+0.1}_{-0.04}$	$42^{+0.4}_{+0.2} \times 17^{+0.1}_{+0.06}$	1 de $251^{+0.5}_{-0.1} \times 10.1 \pm 0.02$

cial maintenance rules have been fixed concerning the play of the brushes in their holder, according to the owing figures :

	In thickness	In width
Allowed when overhauled :	0.05 to 0.28 mm	0.05 to 0.85 mm
Allowed when renewed :	0.05 to 0.18 mm	0.05 to 0.30 mm

limitation of the possible play between brushes and holders is necessary to make sure of the smooth running he brushes and their suitable adaptation to the commutator in order to maintain an acceptable contact current.

TABLE 12. — **Dimensions and tolerances for brushes and brush holders** *(continued).*

HOLLAND					
NETHERLANDS RAILWAYS					
Locomotive series or type					
		1 000	*1 100*	*1 200*	*1 300*
Carbon	height	60	50	60	50
	width	$50^{-0.2}_{-0.35}$	$42^{-0.2}_{-0.35}$	$61^{-0.2}_{-0.35}$	$42^{-0.2}_{-0.35}$
	length	$20^{-0.07}_{-0.15}$	$2 \times (8^{-0.05})$	$2 \times (8^{-0.08})$	$2 \times (8^{-0.05})$
Holder	width	$50^{+0.4}_{+0.2}$	$42^{+0.4}_{+0.2}$	$61^{+0.4}_{+0.2}$	$42^{+0.4}_{+0.2}$
	length	$20^{+0.1}_{+0.2}$	$16^{+0.1}_{+0.05}$	$16^{+0.1}_{+0.05}$	$16^{+0.1}_{+0.05}$

ITALY

ITALIAN STATE RAILWAYS

Brushes	Dimensions : 42 × 15 mm Tolerances : — 0.1 to — 0.2; — 0.03 to — 0.1	No limits are given for the play of the brushes in the holders. Minimum height of brush allowed : 25 mm.
Brush holder	Dimensions : 42 × 15 mm Tolerances : 0 to + 0.1	

NORTH MILAN RAILWAYS

Locomotive series or type	*600*	*700*	*740*	*740*
Carbon brush	$44.9^{+0.1}_{0.0} \times 14^{+0.1}_{-0.0} \times 58$	$40^{+0.1}_{-0.0} \times 20^{+0.1}_{-0.0} \times 55$	$50^{+0.0}_{-0.02} \times 21^{+0.0}_{-0.05} \times 60$	$40^{+0.0}_{-0.1} \times 20^{+0.0}_{-0.05} \times 60$
Brush holders	2 of 24 mm	2 of 14 mm	20 mm	2 of 20 mm

The admissible play between brushes and brush holders is not laid down.

TABLE 12. — **Dimensions and tolerances for brushes and brush holders** *(continued).*

U.S.S.R.		
U.S.S.R. RAILWAYS		
Locomotive series or type		
	Motor type DPE 400	*Motor type NB 406-A*
›es	16 × 50 mm	20 × 50 mm
› holders	$16^{+0.1} \times 50^{+0.15}$	$20^{+0.15} \times 50^{+0.5}$
These dimensions are related to normal working conditions.		

SWITZERLAND			
C.F.F.	*RHAETIAN RAILWAY*		
	Locomotive series or type		
	353 ff	*CC 401-405*	*BoBo 601-610*
›ance for the brushes $^{+0.0}_{-0.075}$ ›ance for the brush holders $^{+0.13}_{+0.07}$ of brushes : max. 0.28 mm min. 0.07 mm	Carbon Ebi 4196 55 × 9 × 40 mm without cable	Carbon Ebj 70 60 × 8.5 × 60 without cable	Carbon Ebj 70 55 × 12 × 60 with two cables

YUGOSLAVIA
YUGOSLAVIAN RAILWAYS
For brushes and brush holders : 15 × 42 mm. No manufacturing tolerances are laid down.

In order to reduce the frequency of operations of replacing the armature bearings, it is always stipulated that high quality metal shall be used for the linings (80 % tin), that the lining shall be done by centrifugation followed by polishing « in line » (en ligne) and polishing the bearing surfaces, as well as machining the journals of the shafts and carefully adjusting the bearings in the body and cap, together with the use of special lubricants.

The tolerances adopted for the axial play of the bearings vary from 0.3 to 1.2 mm, and in the case of the lateral play, from 0.6 to 3 mm as a rule. Finally, as the method of centering, simultaneous centering and machining of the bearing in relation to the cap and inductor is advocated, as well as synchronised tightening up of the fastening bolts.

c) *Bearings of axle or hollow shaft.*

In the case of completely suspended motors with a hollow shaft, it is the current practice to use bronze or steel lined with white metal (antifriction) bearings.

The composition of the lining metal varies between the following limits :

tin	78 to 83 %
antimony	13 to 15 %
copper	6 to 9 %.

On certain railways, the lining metal contains 66.5 to 69.5 % of lead and the proportion of tin is reduced to 14 %.

As for the play and wear allowed, these vary between the following limits :

radial play of the hollow shaft	0.3 to 1.3 mm.
axial play of the hollow shaft	1 to 3 mm.

These limits are established, as is only logical, as a function of the type of locomotive.

d) *Lateral displacement of nose suspended motors.*

In order to avoid shocks due to lateral displacement of the motor against the hubs of the wheels and to keep the gears as central as possible, the Administrations have used special arrangements, such as :

- connecting rod from the motor to the framework of the vehicle;
- suitable design of the axles;
- stop rings;
- brakes on the axis of the motor;
- conical cambered roller bearings in the case of oblique teeth.

Very often use is made of overhauls to the mechanical part of the locomotive to renew the linings of the bearings on their lateral surfaces.

It is necessary to point out that some Administrations do not carry out a special check of the lateral movement of the motors but correct it when the locomotive is out of service for other work.

e) *Roller bearings for the suspension of the motors.*

None of the Administrations consulted has noticed any cracks in the axles due to this type of bearing.

11. a) **Fastening the pinion to the armature shaft.**

The use of a key to fasten the pinion to the armature shaft has been given up at the present time by certain Administrations, in order to avoid weakening the shaft on account of the keyway needed which makes it more apt to crack. In this case, the installation of the pinion involves the following phases :

- cleaning the shaft and the bore of the pinion with a detergent, after getting rid if necessary of any burrs and superficial defects;
- checking the seating of the pinion on the shaft;
- heating the pinion to between 100 and 110° C.;
- further cleaning of the shaft and bore of the pinion;
- assembling whilst checking the penetration of the shaft;
- fitting the pressure washer and the lock nut.

When keys are used for fastening, the pinion is always heated first of all between 80 and 100° in oil, water, or by infra red currents, and then the pinion is fitted and the locknut.

b) Changing the pinion and toothed wheel.

In general, it is not necessary to preserve the original pinion and toothed wheel when owing to some damage, it is necessary to replace a motor on a locomotive. Some Administrations recognise that this is prejudicial to the gears and recommend that it should be avoided whenever possible. For example, there are some Administrations, like the Rhaetian Ry., the U.S.S.R. Railways and North-Milan Rys., who, when they replace a motor, always retain the same pinion-toothed wheel combination as before.

12. Short circuit current with the use of roller bearings.

None of the Administrations consulted have observed any damage to the axles or shaft for the above reason. However, some of them have noticed such anomalies on their windings, and in order to avoid them have had recourse to shunting the latter and earthing them.

13. Replacing traction motors in the depots.

On most of the Administrations, the replacement of the traction motors, whenever necessary, is carried out in the depots without it being necessary to send the locomotive to the main repair shops. Only the C.F.F. and Rhaetian Ry. indicate that this operation normally takes place in large repair shops.

This diversity in the way of proceeding may be due in part to the situation or siting of these general repair shops, and the lesser importance of the depot repair shops.

14. Influence of the type of suspension of the traction motors.

The influence of the type of suspension of the traction motors on their maintenance, on the transmission and on the maintenance of the permanent way, is shown by the fact that in general the cost of repairing nose suspended motors or those having the Sécheron type of suspension, as well as their transmission, is appreciably greater than in the case of completely suspended motors. This influence is accentuated when the speeds exceed 100/120 km/h. However, it is not possible to determine the influence of the type of suspension of the motors on the maintenance of the permanent way, because motors suspended in different ways run over the same lines.

The S.N.C.F. states that it is quite certain that completely suspended motors cause less fatigue to the superstructure, so that they have adopted this arrangement as standard for speeds of more than 105 km/h.

15. Flashovers on commutators.

a) *Frequency.*

Most of the Administrations have no statistics from which to get some idea of the frequency of these flashovers as a function of the mileage, separating as we asked them to do, cases in which it was due to the brushes being earthed from those where it took place between the commutator segments.

The only data supplied on this point were the following :

Algerian Rys. One flashover per 165 494 km (28 months). Out of a total of 14 flashovers, the division was : 4 due to brushes earthing, 10 between commutator segments.

Swiss Federal Railways. 0.3 to 3.2 per 100 000 km for brushes earthing, 0.3 to 5.8 per 100 000 km between commutator segments, according to the series of locomotives.

Austrian Federal Rys. They state that on the series 1020 freight locomotives one flashover occurred every 50 000 to 70 000 km when they were used to haul express trains.

b) *Causes of flashover.*

Amongst the main causes of flashover on the commutator, must be mentioned anomalies due to lack of cleanliness or because of age, insulation defects, excessive electrical tension between the segments and defective applications of the brushes.

In addition to the above causes, due to the design of the motor or the way it has been maintained, there are other outside causes, to remedy which the following steps must be taken :

— The pantograph must constantly absorb any variations in the level of the wire, which means the minimum of weight for the framework and pick-ups;

— Use of only one of the two pantographs usually fitted on each locomotive, especially at speeds above 120 km/h, limiting the use of two pantographs to times when there is ice on the wires, possibly at times in tunnels, and when starting up owing to the intensity of current absorbed;

— Use of double pick-ups on pantographs in the case of D.C.

However, the Italian State Railways, the Jugoslavian Rys. and S.N.C.F., the latter with its single phase 50 cycle types, use single armatures :

— Calculation of the starting resistances in such a way as to make the best possible use of the adhesion;

— Provide a maximum shunting of the motors between certain limits. On non-compensated motors, it should not exceed 55 %, but may reach 80 % on compensated motors;

— Use of maximum overload and over-voltage relays, as well a the use of quick acting circuit breakers to limit peak currents;

— Use of protective elements against atmospheric discharges, for ex. different types of lightning arrestors (condensers, etc.) and reactance coils. Some Administrations prefer to install these protective devices in the substations themselves, for example the Swiss Federal Rys.;

— Use of a device to detect wheel slip by means of a light or close observation of the ammeters. To avoid such slip, various methods are used, such as suitable shunting of the leading motors of each bogie (Algerian Rys.); use of anti-slip relays which put the brake and sanders on automatically and also automatically modify the feed to the motors.

c) *Production of flashovers at certain given spots on the line.*

In general, it is not possible to determine at what spot on the line flashovers occur. However, the S.N.C.F. and Austrian Rys. report respectively that flashover occurs more frequently in the case of nose-suspended motors when passing certain track equipment and near current feed points.

16. Snow getting into the motors.

When it is snowing all the Administrations are faced with the problem of it getting into the motors. This undesirable happening gives rise to flashing in the brush-holders, with the destruction of their insulation, earths the auxiliary poles and certain sections of the armature, and causes roughness of the commutator and unloading of the electro-magnetic valves.

In order to remedy these drawbacks, very varied methods have been used, such as fitting diaphragms in the aspiration ducts of the fans and in the ventilation conduits, strengthening the air inlet valves, closing interior openings, special anti-snow equipment (U.S.S.R.), protective gratings, tissue filters in the ventilation shutters and commutation of the ventilation circuit, taking in air from inside the locomotive.

TABLE 13. — **Lubricants used in the bearings and gears.**

WESTERN GERMANY						
DEUTSCHE BUNDESBAHN						
Bearings						*Gears*
Armature		*Axle or hollow shaft*				
Plain or riction	*Rollers*	*Axles*	*Hollow shaft*	*Suspension nose bearings*	*Reduction gear bearings*	
Light achine oil lidifies 10° C	Grease for roller bearings	Mineral oil	Heavy machine oil	Light machine oil	Mineral oil	Gear grease or oil for superheated steam

ALGERIA			
ALGERIAN RAILWAYS			
Locomotive series	*Bearings*		*Gears*
	Armature	*Axle or hollow shaft*	
CC 6 AE	Esso-Standard oil Movement	Esso-Standard oil Movement	Esso-Standard oil Movement
BB 4 AE	d°	d°	d°

TABLE 13. — **Lubricants used in the bearings and gears** *(continued)*.

AUSTRIA			
AUSTRIAN RAILWAYS			
Characteristics	*Bearings*		*Gears*
	Armature	*Axle and hollow shaft*	
Specific weight at 20 %	$\leqslant$ 0.95	$\leqslant$ 0.95	$\leqslant$ 0.95
Viscosity	At 50° 4-5 E	At 50° for summer 8-10 for winter 4-7.5	At 100° 5-9 E
Inflammability	$>$ 150°	Summer $>$ 160° Winter $>$ 140°	$>$ 300°
Congealment	Liquid at 0°	Summer — 50° Winter — 20°	Liquid at 0°
Neutralisation figures	$\leqslant$ 1.5	$\leqslant$ 1.5	$\leqslant$ 0.7
Content of ash %	$\leqslant$ 0.3	$\leqslant$ 0.3	$\leqslant$ 0.1
Content of hard asphalt %	$\leqslant$ 0.3	$\leqslant$ 1.0	$\leqslant$ 0.1
Content of water %	$\leqslant$ 0.2	$\leqslant$ 0.2	$\leqslant$ 0.5
Residues by Conradson tests	—	—	$\leqslant$ 3

For armature bearings : dynamo oil.
For axle and hollow shaft bearings : axle oil and occasionally oil with very flat viscosity curve.
For the gears : superheated steam cylinder oil.
For the roller bearings of the armature and axle roller bearings: grease. ESSO Andok BR and Socony Vacuum Gargoyle BRB No. 1 are used.

BELGIUM							
BELGIAN NATIONAL RAILWAYS							
Bearings				*Gears*			
Armature	*Axles*			*Locomotive type*	*101 and 120*	*121*	*122 and 123*
ANDOK grease		Summer	Winter	Lubricant	Shell oil	Gargoyl compound	JTM-TM (Sinclair) grease
Brown appearance : flows		SAE 30 oil	SAE 20 oil		S 1 683	6	—
Drip point : 140° C	Viscosity E at 20° C	44	— 26	Viscosity at 50° C	150°	40°	—
Ash : 4.72 %	Density	at 15° C 0.886	0.88 at 20° C	Freezing point	—	— 12°	—
Greasy matter : 92 %	Freezing point	— 18° C	— 15°	Ignition point	230°	182°	—
Consistency at 20° C 292° C	Ignition point	230°	$>$ 260°	Penetration ASTM on grease not worked upon	—	—	320 ± 35

TABLE 13. — **Lubricants used in the bearings and gears** *(continued)*.

LOWER CONGO RAILWAYS			
Bearings			*Gears*
Armature (roller bearings)		*Axle or hollow shaft*	
3 62 type grease		First grade pure mineral oil	PEN-D. LED EP 8 of ESSO Standard
ent :	lithium soap	Shell Tampa 40 (CV 3)	—
ium soap :	maximum 12 %	Viscos. at 50°C: 13.5 E approx.	175° E
e soap :	nil	Viscos. at 100°C: 2.25 E approx.	11° E
point ASTM :	180° C minimum	—	Freezing at + 4° C
tration at 25° C	220-250	—	—
orked on grease :	10-2 cm	—	—
stance to separation heating for 5 hours 125° C (expressed % of separated oil)	For lithium soap content of : > 10 % = 5 % max.; for < 10 % = 7 % maximum	—	—

SPAIN	
R.E.N.F.E.	
Bearings	*Gears*
CAMPSA — 55/19 Machine oil M-2 (ST-178) SAE-60 and D-16	CAMPSA free flowing grease CAMPSA 47 CAMPSA SAE 40 Shell Corbula « C » grease SAE 60, SAE 40 and D 26 CAMPSA H7 72-12 Compound D, Corbula D SAE-60 grease is used in summer SAE-40 grease is used in winter

TABLE 13. — Lubricants used in the bearings and gears (continued).

FRANCE							
FRENCH NATIONAL RAILWAYS							
[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]			
Ignition point in closed container	[illegible]	[illegible]	[illegible]	[illegible]	—	—	[illegible]
Fusion point °C	< — 15	< — 10	< — 5	< — 5	—	—	[illegible]
Kinematic viscosity in centistokes at 25° C	—	—	200 to 320	320 to 480	—	—	[illegible]
at 50° C	65 to 80	100 to 120	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
at 100° C	[illegible]	[illegible]	[illegible]	[illegible]	—	—	[illegible]
Index of acidity	[illegible]	[illegible]	[illegible]	[illegible]	—	—	[illegible]
Index of saponification	[illegible]	[illegible]					—
Ash	< 0.05	< 0.05	< 0.1	< 0.1	—	—	—
Hard asphalt %	—	—	[illegible]	[illegible]	—		
Matter insoluble in benzene	—	—	[illegible]	[illegible]	—	—	—
Mineral oil content	—	—	—	—	[illegible]	[illegible]	—
Petroleum pitch content %	—	—	—	—	[illegible]	[illegible]	—

NETHERLANDS			
NETHERLANDS RAILWAYS			
Locomotive [illegible]	[illegible]		[illegible]
	[illegible]	[illegible]	
1 000 1 100 1 200 1 300	SAE - [illegible] SAE - [illegible] SAE - [illegible] SAE - [illegible]	SAE - [illegible] SAE - [illegible] SAE - [illegible] SAE - [illegible]	[illegible]

TABLE 13. — **Lubricants used in the bearings and gears.**

ITALY		
ITALIAN STATE RAILWAYS		
Bearings		*Gears*
Armature	*Axle or hollow shaft*	
...ase formed of sodium and potas- ...m compounds. ...M penetration at 25° C, 225- ... dmm.	Pure mineral oil. Viscosity 9 to 12 Engler at 50° C. Index of viscosity > 30. Point of flow 15° Ignition point 190° C in open container.	Grease composed of bitumen and cylinder oil, summer and winter types. Redwood No. 2 viscosity in centistokes. summer type : at 140 F from 6 000 to 7 000 at 200 F from 350 to 400 winter type : at 140 F from 2 500 to 3 000 at 200 F from 270 to 300

ITALY		
NORTH MILAN RAILWAYS		
Bearings		*Gears*
Armature (roller bearings)	[illegible]	
...grade grease «Purfina Marson» ... 2 with sodium base. Drip point ...-160° C.	Winter : « Purfina-Anrion 55 » oil. Specific weight : 0.92-0.93. Viscosity : at 50° C 12° E; at 100° C 2° E. Ignition point in open flask 220° C. Organic acidity < 0.1. Freezing point — 15° C. Summer : «Purfina Anrion 65» oil. Specific weight 0.92-0.93. Viscosity : at 50° C 22-23° E; at 100° C 27-28° E. Ignition point in open flask 240° C. Organic acidity < 0.1. Freezing point — 5° to — 10° C.	Winter : « Reinach-Metaor » C grease Viscosity : at 75° C 233° E; at 100° C 38° E. Summer : « Reinach-Metaor » D grease. Viscosity : at 75° C 339° E; at 100° C 60.05° E.

TABLE 13. — **Lubricants used in the bearint and geras** *(continued).*

U.S.S.R.							
U.S.S.R. RAILWAYS							
Bearings					*Gears*		
Armature		*Axles*					
Consistent lubricant "1-13"		Industrial oil of two types	"45" (Summer)	"30" (Winter)	Transmission oils	(Winter)	(Summer)
Drip point > 120° C.		Viscosity at 50° :			Cohesion at 100°	2.7-3.2	4.0-4.5
Engler viscosity at 25° C : 250-290		a) kinematic	38-52	27-33	Ignition in open flask °C	< 170	< 180
Engler viscosity at 40° C : > 30		b) conditions towards 7°	5.24-7.07	3.81-4.59	Freezing point	<— 20	<— 5
Oil separation lubricant : nil		Acidity in mg of KOH per g of lubricant	< 0.35	0.2	Soluble acids and alkalis	nil	nil
Free base %	< 0.2	Carbonisation degree %	< 0.3	0.3	Mechanical constituants %	< 0.05	< 0.05
Water %	< 0.75	Salts	< 0.007	0.007	Water % maximum	trace	trace
		Ignition in open flask °C	> 190	180			
		Freezing point °C	<—10	15			
		Soluble acids and alkalis	nil	nil			
		Mechanical constituants %	< 0.007	0.007			
		Water %	nil	nil			

SWITZERLAND						
C.F.F.			*RHAETIAN RAILWAY*			
Bearings		*Gears*	*Type of locomotives*	*Bearings*		*Gears*
Armature	*Axle or hollow shaft*			*Armature*	*Axle and transmission*	
Dynamo oil or grease	Machine oil	Machine oil or plastic oil (mixture of oil and grease)	I D I	Pump oil 16/78	Machine oil	Perol
			C C	Valvulina AAA	Machine oil	Perol
			Bo Bo	Grease SKF 28	SKF 28	Shell Fiona 81

YUGOSLAVIA
YUGOSLAVIAN RAILWAYS
Like the railways of Central Europe.

On the modern S.N.C.F. locomotives, dust extractors have been installed which also pick up the flakes of snow.

On the Austrian Rys., a study is now being made of increasing the pressure and temperature in the equipment compartments.

IV.

IV. LUBRICANTS USED ON LOCOMOTIVES.

1. Types of oil used on the different types of electric locomotives.

Table 13 appended includes the characteristics of the oils and grease used at different times of the year by the Administrations who change the lubricants according to the outside temperature.

As will be seen from this table, most of the Administrations change the type of oil according to climatic conditions and variations in temperature throughout the year.

There are some like the C.F.F. which only change the oil used in the S.L.M. universal drive, using engine oil in winter and cylinder oil in summer.

Changes of lubricant are usually made by progressively replacing that already in the boxes and grease cups by successive toppings up after the due dates.

The only Administration which indicated that it first of all emptied the gearbox to change the oil is the North-Milan Co.

2. Use of additions such as molybdenum bisulphide to the lubricants used.

None of the Administrations consulted use molybdenum bisulphide as an addition to the lubricants used; consequently, they were not able to give any information on the results this might give.

Nor do they use any special methods for applying the lubricants to the gears, for example using measured amounts in polythene bags. Only the S.N.C.B. has tried this method on the classes 122 and 123 locomotives, but it appears that it has been given up on account of its excessive cost.

Finally, we asked if it was possible for the lubricant used in the gears to affect the suspension bearings of the motor, and vice-versa, as well as the remedies tried if so. Most of the Administrations replied in the negative, except the S.N.C.B., N.S., S.N.C.F. and Jugoslavian Rys. who stated that they had sometimes noticed in service penetration of the lubricant of the bearings into the gearbox and gears and vice-versa, and had taken constructive steps to remedy this, amongst others improving the tightness of the joints in the gearboxes and eliminating differences in pressure, either by making balancing ducts or facilitating communication with the atmosphere.

V.

V. WEAR OF THE PANTOGRAPH STRIPS.

1. Wear of the pantograph rubbing or contact strips.

In *Table 14*, we have collected together the replies from the different Administrations concerning the contact strips of pantographs. This shows the material of which these strips are made, their number and size, method of fixing to the pick up bows, precautions taken to avoid arcing between the strip and the pick up bow and the maximum wear allowed on the strips.

TABLE 14. — **General dimensions of**

Ref. No.	*Country*	*Administrations*	*Number of strips*
1	*WESTERN GERMANY*	*Deutsche Bundesbahn*	-
2	*ALGERIA*	*Algerian Railways*	16 divided among 2 armatures of 2 rows of 4 strips.
3	*AUSTRIA*	*Austrian Railways*	Old type : 1 per pick-up. Modern type : two per pick up.
4	*BELGIUM*	*Belgian National Railways*	3 per armature.
5	*BELGIUM (Colony)*	*Lower Congo to Katanga Railway*	2 per pantograph.
6	*SPAIN*	*R.E.N.F.E.*	2 per pantograph in 3 pieces.
7	*FRANCE*	*French National Railways*	8 per pantograph 1 500 V,D.C. 4 per pantograph 1 500 V,D.C. 2 per pantograph - 25 000 V, single phase
8	*HOLLAND*	*Netherlands Railways*	3 per armature.
9	*ITALY*	*Italian State Railwaus*	3
10	*ITALY*	*North Milan Railways*	1 or 2
11	*U.S.S.R.*	*U.S.S.R. Railways*	2 per armature.
12	*SWITZERLAND*	*C.F.F.*	2 per pantograph.
13	*SWITZERLAND*	*Rhaetian Railway*	2 per double armature.
15	*YUGOSLAVIA*	*Yugoslavian Railways*	2

g strips of pantographs.

nensions en mm	*Material*	*Fastening*	*Measures taken to avoid arcing between the strip and the bow*	*Maximum wear allows*
× 36 × 1 300	Carbon	*Screws*	Correct design without any special measures.	5-6 mm
25 × 200	Copper graphite	Clip	By covering the strips with copper and keeping them very tight.	17 mm
× 36 × 900 × 20 × 1 000	Carbon covered with aluminium. Carbon.	— Welding.	No arcs occur.	30-20 mm
× 35 × 1 100	Non-metallised carbon.	Embedded in copper duct.	No arcs occur.	25 mm
30 × —	Carbon.	Embedded in copper duct.	—	20 mm
iece of 50 × 5 × 623 ieces of 30 × 5 × 298	Electronic copper.	Screw	No arcs occur.	4 mm.
7 × — 25 × — 7 × —	Copper and steel Carbon Steel	Bolts Dovetail Bolts	No special arrangements	4 mm. 15 mm 4 mm
of 30 × 26 × 940 of 30 × 26 × 470	Carbon with copper and lead MY 7 D	Vice	—	16 mm in height
of 35 × 6 × 540 of 72 × 6 × 980	Copper Steel	Screw	No special arrangements	Minimum thickness 2 mm
× 10 × 950 × 12 × 1 184	Bronze	Screw-eye	Copper bands at the joints	No definite value
6 thickness	Copper	Screw	By fastening screws in copper or brass	Minimum thickness 2.5 mm
0 × 16 × 600	Aluminium, copper and carbon	2 Screws	No arcs occur	Minimum thickness Aluminium 4 mm Winter 8 mm Minimum thickness Copper 3 mm Minimum thickness Carbon 5 mm
) × 16 × 1 030) × 13 × 870	Aluminium alloy	4 M 8 type Screws		Minimum thickness 4 mm
5 × 8 × —	Copper	Bolts	Arc protector of the armature	Minimum tickness 1 mm

As will be seen from this table most of the Administrations continue to use the classic materials for making these strips, such as steel, copper, aluminium and carbon, to exclude the captation of current by vitrified metal. There is however a tendency to use carbon, because this seems to combine all the most favourable conditions from the point of view of life and facility of making contact.

The North-Milan Rys. have tried various copper alloys, and have come to the conclusion that the most suitable has the following composition :

copper	65 %
lead	30 %
tin	4.6 %
nickel	0.4 %.

The Italian State Railways have also tried a sintered material in order to avoid the dangerous rise in temperature which occurs on the contact line when carbon is used; finally the U.S.S.R. Rys. are now making tests for replacing the strip of copper by graphited steel.

The pantographs are lubricated by placing the lubricant in the grooves between the strips. The most usual types of lubricants used are : *Spidoleine* (graphited grease with 80 % grease and 20 % powdered graphite) and *Solidoil* with graphite.

Some Administrations, such as the S.N.C.F., add 5 % paraffin to the graphited grease in winter.

The U.S.S.R. Rys. have tried for some years apparently with success using solid graphite (65 % graphite and 35 % resine).

The lubricant is generally applied by hand, with a spatula, or by the motorman when beginning work, or by the depot staff whilst inspecting various parts of the locomotive. Only the solid graphite tested by the U.S.S.R. is applied in a melted state to the bow which is heated after it has been removed from the pantograph and is then replaced in its proper position.

There are no special arrangements in the depots for the rapid greasing of the pantographs and their strips.

As regards the frequency with which the pantographs are lubricated, nearly all the Administrations do it whenever necessary independently of repairs or inspections of the locomotive. Only the S.N.C.B., Algerian Rys., C.F.F. and Rhaetian Ry. make the greasing of the pantographs coincide with periodic inspections or repairs.

2. Frequency with which strips are renewed.

As is natural, the frequency with which the strips have to be renewed, expressed either in mileage run or period of time, is not uniform on the different Administrations, seeing that it depends, logically, on the working conditions of the locomotives. In general, it is possible to count upon an average mileage of 60 000 to 80 000 km. There are some Administrations where renewal takes place much more frequently, for ex. the F.S. and R.E.N.F.E. where it takes place every 8 000 to 12 000 km. On the other hand, other Administrations, such as the Lower Congo, renew them every 100 000 km, which means approximately 8 months in service. Finally, the information we got from the C.F.F. shows that when using aluminium strips, renewal is necessary in winter every 15 000 to 25 000 km; in summer, every 6 000 to 8 000 km; whilst with carbon strips it is necessary after about 50 000 to 90 000 km. In the same way, the U.S.S.R. Rys. renew them every 15 000 to 20 000 km when they use the old lubricant, 30 000 to 40 000 km when they use solid graphite and 10 000 km with graphited solidoil.

Conditions seem to be similar on the Netherlands Railways, who renew every 27 000 to 34 000 km according to the type of locomotive.

3. Influence of climatic conditions and the type of service on the wear of the strips.

All the Administrations stated unanimously that the wear of the strips is relatively greater in winter than in summer,

because of ice and frost deposited on the pantograph and contact wire.

As regards the influence of the type of service, the S.N.C.F. and S.N.C.B. agree in stating that wear is greater in the case of stopping services and mixed services than with express locomotives (up to 30 % greater in France). On the other hand the Deutsche Bundesbahn stated exactly the contrary, i.e. wear is 30 % greater on the fast vehicles than on the slow; perhaps the type and tension of the current used have an influence upon these results.

4. Replacing the strips.

Most of the Administrations replace the strips and bows of the pantographs in the depots. Only the Jugoslavian Rys. and C.F.F. renew the strips « in situ » in case of need, but the replacement of the bows is generally done in the depots.

5. Factors which can also affect the wear of the rubbing strips.

From the replies received to our questionnaire, we were not able to get any exact figures concerning the influence upon the wear of the rubbing strips of other operating factors such as the pressure of the pantograph on the wire, the amount this is out of centre, the intensity of the current picked up, the relative hardness of the metal used for the contact wire and the material used for the strip, etc. The majority of Administrations merely contented themselves with indicating :

a) that the wear increases with the pressure of the pantograph on the wire;

b) polygonal stagger of the contact line favours the maintenance of the strips and distribution of the lubricant.

c) wear increases with the intensity of the current picked up, but the influence of this factor is less than that of the above two;

d) the hardness of the metal used for the contact wire and for the pantograph strips should be more or less similar, to avoid rapid wear of one or the other.

6. Methods intended to prevent ice adhering to the pantograph strips.

These methods depend upon the type of lubricant used by the Administrations. For ex. on the U.S.S.R. Rys., graphited solidoil is not used when temperatures below —30° C are expected. On the North-Milan Rys., holes are provided under the strip to get rid of any water, and on the D.B. strips divided into small sections are used.

None of the other Administrations appear to have taken any steps in this connection.

7. Frequency with which pantographs are inspected.

Generally, two types of inspection are carried out with the pantographs, according to the periods at which work is done on the locomotive :

a) During small repairs, sometimes carried out by the engine crews, a check is made of :
- — the wear of the strips;
- — the cleanliness of the supporting insulators;
- — the lubrication of the strips, if necessary, and the joints of the pantograph;
- — the proper functioning of the pantograph.

b) During important maintenance work carried out in the depots, a check is made of :
- — deformations of the pantograph;
- — the shunts and connections are checked;
- — the contact pressure and tightness of the pneumatic equipment.

The frequency of these operations varies between 2 and 3 times a day and once a week for the small maintenance jobs and between 3 and 4 months for the more important work.

The S.N.C.B. controls the pressure on the contact wire which should be 7.5 kg ± 15 % by checking the lifting up of the pantograph with a weight of 6.375 kg and

its descent with a weight of 8.625 kg between 4.8 and 6.25 m above the rail.

Finally, as regards special arrangements made in the depots to facilitate the maintenance of the pantographs, by using for example mobile or fixed working platforms, the Administrations have not all provided special equipment of the type in question in their establishments. Those who have them use fixed and mobile platforms indiscriminately.

The U.S.S.R. Rys. in addition to these types of platforms use special devices to check abnormal deviations of the pantographs in service.

VI.

VI. ORGANISATION AND PERIODICITY OF LOCOMOTIVE MAINTENANCE WORK.

1. General considerations.

As we stressed above, in general the locomotives are given a cursory inspection when put into work. This inspection takes place in the depot every 1 to 4 days. Maintenance operations are carried out respectively every 200 000 to 300 000 km and 500 to 600 000 km according to whether they are intermediate overhauls or general overhauls.

It is easy to understand why the periods at which repairs are carried out vary so much according to the type of locomotive and service for which it is used. Thus, for example the Austrian Rys. carry out periodic repairs, according to their importance, every 4 500 to 10 000 km, partial overhauls between 80 000 and 300 000 km and general overhauls between 240 000 and 900 000 km.

Other Administrations (Deutsche Bundesbahn) carry out periodic work every month, completed by other overhauls every 3, 6 and 12 months. They also fix an interval of a year and a half to two years between intermediate overhauls and another of three years between general overhauls, making the latter coincide with an intermediate overhaul.

It is natural that the Administrations should be concerned to space out these operations as much as possible, in order to get the best possible user of the locomotives, as well as a reduction in maintenance costs, by adopting steps to retard the reduction in the traction capacity of the engine. This is why the design is constantly being improved which must necessarily affect the inspections and overhauls, such as for example the use of rail lubricators, improvements to the axles, rings, roller bearings, etc. as well as the quality of the spares by improved manufacture and adequate training of the staff carrying out maintenance work.

2. Limiting factors influencing the periodicity of repairs.

It is obvious that the periodicity of these inspections and maintenance must be influenced by certain factors which can modify the above mileage and times. These factors can be roughly grouped under the following headings :

- control of safety components (tyres, brakes, etc.);
- premature wear of the brushes;
- incidents affecting control equipment during service;
- detection of cracks in the bogies;
- abnormal wear of the pantograph strips;
- loss of insulation in the cabling;
- abnormal wear or ovalisation of the commutators;
- faulty behaviour of the roller bearings and bearings.

These anomalies may result in the renewal of parts which if left on the engine might endanger its safety; others might also be added, such as springs that have lost camber, shafts with excessive wear, etc.

3. Work done during overhauls.

For the same reason, the work carried out by the different Administrations, their grouping and their periodicity, vary from one to the other. For an example of the

way these operations are carried out and to show what each of these overhauls includes, we have taken the reply of the S.N.C.B. which gave at greater length than the other Administrations the details we wished to know. According to the type of overhaul, the work involved in each case is as follows :

A. *Small maintenance.*

1. *Electrical part.*

Checking the starting gear, the motors, pantographs and roof insulators.

2. *Mechanical part.*

Replacing the brake shoes, inspecting the bogies to find any cracks, and examining the fastenings and condition of the parts. Compressed air and vacuum equipment. Greasing the connections. Cleaning.

B. *Heavy maintenance.*

In addition to the small maintenance jobs, the following are carried out.

1. *Electrical part.*

Complete inspection of the equipment and summary cleaning. Checking and tightening up the connections, contacts and blow-out devices, automatic and manual starting, dead man's handle and gauges.

2. *Mechanical part.*

The same work as during small maintenance.

C. *Intermediate overhaul.*

1. *Electrical part.*

Measuring the L.T. and H.T. insulation. Greasing the pantograph cylinders. Cleaning the traction motors and rectifying the commutator; painting and varnishing insulating parts. Thorough cleaning and measuring the starting resistances and equipment. Checking the contacts, blow-out devices, relays, tension regulators (L.P.) and cut-outs, including verification of the pressure, if necessary, and replacement if necessary. Rectification of the commutators of the auxiliaries.

All the work included in heavy repairs.

2. *Body.*

Cleaning and painting the roof, interior, corridors and driving compartment. Checking the connections between bogies, the buffing and drawgear, the brake rigging. Cleaning the brake cylinders. Thorough check of the tightness of the compressed air pipes and all cocks and fittings.

3. *Bogies.*

Turning the wheels. Checking, cleaning and replacing if necessary the axle bearings and traction motor bearings. Renewing the joint packings of the bearings and gearcases. Dismantling the brake rigging and replacing worn brushes and pins. Detailed examination of the suspension and connections between bogies and body.

D. *General overhaul.*

1. *Electrical part.*

Complete overhaul including dismantling the pantographs, traction motors and auxiliary groups, quick-acting circuit breakers, servo-motors with cam shafts, certain H.T. contacts and checking the H.T. and L.T. electric conduits.

2. *Body.*

Painted throughout, inside and out. Repairing all cocks and fittings and the brake gear. Repairing the doors and floors.

3. *Bogies.*

Completely dismantled. Detailed check of the gears. Replacing the joint packings of the bearings and gearbox, as well as the worn pins and bushes.

This general overhaul includes all the operations carried out in the former overhauls, so that the locomotives at the end are in the same condition as when they were first put into service.

All these operations and the similar ones reported by the other Administrations are carried out by taking the locomotive into the depots, so that the main repair shops, which are much larger than the depots are reserved for general overhauls.

4. Length of time the locomotive is immobilised for each of these overhauls.

It is obvious that the time taken for the inspections, maintenance operations and periodic overhauls depends upon the type of locomotive and the spares and equipment available in each case. However the following figures can be taken as averages :

Daily inspection . . .	30 to 60 minutes
Summary inspection . .	3 hours
Periodic overhauls . . .	8 hours
Intermediate overhauls .	10 to 20 hours
General overhaul . . .	1 to 2 months.

In order to reduce the time of immobilization as much as possible, care is always taken when designing new locomotives to make all the different parts as accessible as possible so that they can easily be cleaned, repaired or replaced, as well as the use of blocks of precabled apparatus, grouping the gauges, etc.

The time of immobilization is also reduced by taking care that the operations are carried out by drawing parts out of stock, i.e. by always having spares available; for example the bearings for the traction motors and auxiliaries, cable rollers, contacts, etc., either new or reconditioned.

Finally, standardisation and scientific organisation of the work in the depots and repair shops, as well as constantly improving their equipment as regards inspection pits, lifting gear and tools also effectively reduce the time of immobilization.

5. Systems adopted for the organisation of the programme of inspections and periodic overhauls.

The work of maintenance and periodic overhauls is drawn up by the depots in collaboration with the regional or central departments, according to the mileage, condition of the locomotive and repair and maintenance programme for the motor stock as a whole, for periods of 6 to 12 months.

In cases where a bogie or another important part has to be replaced, the operation is always carried out in the depots and small traction repair shops attached to them. The Rhaetian Ry. is an exception to this rule, as operations of this type are always carried out in the main repair shops.

6. Influence of the increased speed of the locomotives on the amount of damage occurring.

From the information received, it appears that the speed has very little influence upon causing damage during running and mainly affects the mechanical parts, which is not surprising, as the locomotives were designed to run at the speeds which they normally reach in service.

VII.

VII. ORGANISATION OF THE ENGINE CREWS AND INFLUENCE OF COMMON USER OF THE LOCOMOTIVES.

1. General.

All the Administrations, except the R.E.N.F.E., North-Milan and Jugoslavian Rys. change the train crews during the journey.

It is obvious that a change of crew is the more necessary the longer the runs made by the locomotives, because it often happens that there is insufficient time between the arrival of a train and the departure of the same locomotive on the next train for the crew to have enough rest.

As regards common user of the locomotives, there are a great many Administrations on which such common user has been completely realised in order to get better user of the locomotives without any disadvantages as regards their inspection and maintenance. We may quote as examples : the S.N.C.F., F.S. in the case of freight services, N.S., C.F.F., Rhaetian Ry., S.N.C.B., etc.

Other Administrations, for example the F.S. in the case of passenger services, and the R.E.N.F.E. allocate each locomotive to a certain number of drivers, between 1 and 3 according to the service. These Administrations state that this system has the advantage of the engine crew having in this way a much more thorough knowledge of their locomotives, which reduces damage, and is perfectly compatible with a good user of the motor stock. Nevertheless, these Administrations are introducing common user of all their locomotives as the length of the electrified lines increases.

The common user of the locomotives has no repercussions upon the periods considered necessary for carrying out inspection and maintenance operations; on the contrary, in many cases, it has greatly facilitated the organisation of this work.

2. Stabling the locomotives in the large stations.

In general, the locomotives only go back to the depots when it is necessary to carry out some maintenance work on them. There are however some cases in which the locomotives go back to the depots, either for the daily inspection, or to put them under cover in order to save them from the weather, or to change the engine crews, or for reasons of a social nature (dormitories and canteens).

When the locomotive is immobilized because it is not needed or because maintenance work has to be carried out on it, it frequently happens that it is stabled in the station, or on a siding, rather than in the depot. These sidings are often equipped with inspection pits for the convenience of inspection and any small repairs that may be required.

Stabling in the stations or sidings may have the advantage of convenience for the staff, and allows the locomotive to be put into work very quickly. On the other hand, it has serious drawbacks in the case of very low temperatures accompanied by frost, snow, etc.

3. Recruiting the engine crews.

In general, the drivers of the electric locomotives are recruited from the former steam engine drivers, as the change in traction progresses. At the same time, men are recruited directly for the job. In both cases, the men undergo a period of technical and practical training, because it has been noted that men used to steam traction, either on account of their age, or because of the harder work involved on a steam locomotive, or through lack of technical knowledge, adapt themselves very poorly to the characteristics of electric traction.

On the whole, the Administrations consulted stated in their replies that suitable training of the engine crews tends to reduce the number and seriousness of possible incidents occuring to the motor stock in service, but in spite of this they have not noted any appreciable variation in the periods after which inspection and control operations have to be carried out.

4. Participation of the engine crews in the work of maintaining and repairing their locomotives.

In general, the drivers make a superficial inspection of the locomotive at the beginning and end of the run. During the latter inspection, they note any anomalies or damage which may have occurred in order to get these repaired; but except in the U.S.S.R., or in very special cases, they do not carry out any maintenance work; and if they do, it is always very elementary.

On the U.S.S.R. Railways the following jobs are done by the engine crews:

— regulating the brakes;
— checking the armatures, bearings, axles, gear wheels and transmission;
— tightening up the bolts of axleboxes and casings;
— replacing screws, bolts, pins and cotters;
— eliminating leaks in the air conduits;
— attending to lubricant piping and cleaning the outlets;
— examining, cleaning and greasing the pantographs;
— tightening up pins and the fastening of the suspension;

— cleaning the contacts and segments;
— replacing the brushes, cleaning the brush-holders and auxiliary equipment;
— regulating the accoustics signals and replacing the diaphragms;
— repairing any damage to the light signals; replacing fuses.

5. Influence of the system of user of the locomotives on maintenance costs.

Many of the Administrations consulted were not able to give concrete information about this influence. Others found from experience that the cost of maintenance per km of locomotive is reduced when the distance covered per unit of time increases, so that in general it can be expected that these maintenance costs, like those of putting the locomotive into service, decrease with the intensive user of the motor stock.

VIII.

VIII. COST OF REPAIRS AS A FUNCTION OF THE TYPE OF EQUIPMENT AND AGE OF THE LOCOMOTIVES.

1. General.

From the replies received it appears that there is great heterogeneity as regards maintenance operations which even when they are called by the same names are of differing importance. On the other hand, the figures for the general overhauls are fairly uniform.

In Paragraph VI-3, we have taken as example for the repairs the S.N.C.B. To fix our ideas and retain a certain unity, we will also take the hours fixed by this Administration for the different operations, which are the following :

	Hours
Slight repairs or maintenance	14 to 21
Heavy repairs of maintenance	32 to 40
Intermediate overhauls . . .	450 to 850
General overhaul	4 000 to 5 000

As regards the expenditures relative to the maintenance and repair operations and taking into account that they are sometimes different operations, we can express these costs as a percentage of the value of the engines as at 1955 costs, for the Administrations as a whole, by the following *average figures,* deduced from the data received :

Slight maintenance . .	Labour	= 0.08 %
	Materials	= 0.03 %
Heavy maintenance . .	Labour	= 0.42 %
	Materials	= 1.13 %
Intermediate overhaul .	Labour	= 1.95 %
	Materials	= 1.93 %
General overhaul . . .	Labour	= 5.71 %
	Materials	= 8.92 %

2. Variation of these prices as a function of the type of equipment and age of the locomotive.

The Administrations did not give any concrete replies to this question, perhaps because they had none to give, due to the comparative newness of most of the electric locomotives now in service.

However, some of them stated that these costs increase with the number of driving axles, and when these are connected by rods, they are 25 % higher.

On the other hand, if the age of a locomotive characterises so to speak the technical level of the period in which it was designed, the additional costs inherent in the ageing of the material are often more than made up by a judicious selection of the repair cycles, of the improvements which can be made during repairs, and finally by the different modifications made to the locomotive to improve the original arrangement.

What is certain is that as a whole all the Administrations tend to increase the period between general overhauls on account of the cost of the latter. For example the North-Milan Rys. endeavour to reach a figure of 1 000 000 km and have recourse to private industry for specialist jobs, limiting the use of their own depot staff to inspections, periodic maintenance operations and intermediate overhauls.

The most rational policy to obtain better user of the capital invested in the motor stock can be synthetised under the following headings :

a) Improving the existing locomotives;

b) Rationalising the maintenance work;

c) Reducing the cost of power and labour for driving;

d) Fabrication of spares in special shops;

e) Increasing the periods between overhauls;

f) Designing new series of locomotives, trying to standardise to the greatest possible extent.

APPENDIX.

RAILWAYS OF THE POLISH PEOPLES REPUBLIC.

POLISH PEOPLES REPUBLIC.

Ministry of Communications.

As we stated in the report, the figures concerning the railways of the Polish Peoples Republic arrived very late, so that it was not possible to include in the tables the specific figures for this Administration.

In general, the replies received from this railway to the questionnaire were taken into account in the text of the report; we give below the figures that would have been given in the tables.

I. General information.

1. *System of electrification and length of electrified lines.*

3 000 V D.C. is used; 486.34 km of double tracks are electrified.

As regards the total length of electrified lines, the whole of the main and secondary lines amount to 1 465 km.

In the next few years it is proposed to electrify a further 900 km of lines.

2. *Principal characteristics of the locomotives.*

The table appended gives all the fundamental data concerning the different types of electric locomotives in service.

3. *Braking system.*

As on all the Administrations who replied to the questionnaire brakes acting by pressure of cast iron shoes on the tyres are used. As regards the method of working the brakes, compressed air braking is used; electric brakes are not used in any form, neither rheostatic nor regenerative brakes.

4. *Train speeds.*

The maximum speed authorised in general for the trains is 100 km/h.

As for the approximate average speed, this is 75 km/h for passenger trains and 44 km/h for freight trains.

II. Wear of the tyres.

Monoblok wheels are not used on this Administration and no changes have been made in the quality of steel used for tyres when changing over from steam to electric traction.

The maximum wear allowed between two successive turnings is 10 mm and the total maximum wear of the running surface is fixed at 40 mm. The mileage between two successive retreadings is about 100 000 km.

The mechanical characteristics and chemical composition of the steel used for tyres are as follows :

Breaking resistance . . . . . 70 kg/mm²
Brinell hardness 200
Chemical analysis : C = 0.55 %
P = 0.06 %
S = 0.05 %.

No modification was made in the steel used for rails when changing the system of traction; its mechanical characteristics are as follows :

Breaking resistance . . . . . 80 kg/mm²
Brinell hardness 230
Minimum elongation . . . . 7 %

Automatic rail lubricators are not used, nor flange lubricators mounted on the locomotives.

Locomotive characteristics.

Spécification	SERIES				
	E 01	E 02	E 03	E 04	E 05
Year of construction	1 934	1 953	1 951	1 953	1 954
Electrical part-Builder	M.V.	M.V.	ASEA	LEW.	LEW.
Mechanical part-Builder	Chrzanów	Pafawag	ASEA	LEW.	LEW.
Length between buffers	13 564 mm	15 000 mm	14 170 mm	16 370 mm	18 500 mm
Axle arrangement	Bo.Bo.	Bo.Bo.	Bo.Bo.	Bo.Bo.	Co.Co.
Length between bogie pivots	6 477 mm	7 450 mm	6 800 mm	7 800 mm	7 750 mm
Weight in running order	75.2 t	81 t	81.2 t	86 t	113.3 t
Weight of the electrical part	31.5 t	31.5 t	—	40.5 t	—
Weight of the mechanical part	43.7 t	49.5 t	—	45.5 t	—
Load per motor axle	18.8 t	20.25 t	20.3 t	21.5 t	18.9 t
Nominal service tension	3 000 V	3 000 V	3 000 V	3 000 V	3 000 V
Continuous rating speed	68 km/h	68 km/h	68 km/h	48 km/h	48 km/h
One hour rating speed	63.7 km/h	63.7 km/h	63 km/h	45.8 km/h	46 km/h
Terminal tension	1 500 V	1 500 V	1 500 V	1 500 V	1 500 V
Continuous intensity	246 A.	246 A.	270 A.	324 A.	324 A.
One hour intensity	300 A.	300 A.	325 A.	380 A.	380 A.
Number of revolutions - continuous rating	930 r.p.m.	930 r.p.m.	1 050 r.p.m.	735 r.p.m.	735 r.p.m.
Number of revolutions - one hour rating	870 r.p.m.	870 r.p.m.	950 r.p.m.	700 r.p.m.	700 r.p.m.
Motor suspension type	tramway	tramway	tramway	tramway	tramway
Transmission type	69/22	69/22	83/24	81/21	81/21
Diameter of traction wheels	1.220 m	1.220 m	1.220 m	1.350 m	1.350 m
(a) new tyres	1.220 m	1.220 m	1.220 m	1.350 m	1.350 m
(b) tyres after first turning	—	—	—	—	—
Brakes	compr. air Knorr	compr. air Knorr	compr. air Westingh.	compr. air Knorr	compr. air Knorr
Maximum speed	100 km/h	110 km/h	110 km/h	120 km/h	110 km/h
Coupling between bogies	Rigid Cardan joints	Without coupling	Elastic buffers	Elastic rods	Transversely elastic Cardan joints

III. Maintenance of the traction motors.

1. *Characteristics of the traction motors.*

	MV.185	MV.185.R	LJB.117	GBM.530
No. of main poles	4	4	4	4
No. of auxiliary poles	4	4	4	4
No. of brush-holders	4	4	4	4
No. of commutator segments	400	400	378	462
No. of brushes per holder	2	2	2	2
Type of armature bearing	friction	roller	roller	roller
Type of suspension bearing	friction	friction	friction	friction
Class of insulant	K.L.B.	K.L.B.	K.L.B.	K.L.B.
Method of greasing suspension bearings	by means of a wool wick in a bath of olive oil			Wool bearings with wicks in olive oil bath
Weight of motor with gearbox	4815	4815	4637	6250
Weight of motor without gearbox	4400	4400	4275	4900

2. *Transmissions.*

MV 185 & MV 185 R : Unilateral drive with rigid crown and straight teeth. Welded gearbox of steeled white iron. For greasing transmission lubricant is used.

LJB 117 : Bilateral drive with rigid crown and oblique teeth. Welded gearbox of steeled white iron. Transmission lubricant.

GBM 530 : Rigid bilateral drive with oblique teeth. Light cast gearbox. Transmission lubricant.

3. *Brushes and brush-holder.*

Type of motor	Dimensions of brushes	Dimensions of play between the brushes and brush-holders in their cages
MV. 185	$48^{+0.00}_{-0.20} \times 14^{+0.00}_{-0.10} \times 63.5$	in width . min. 0.05 mm. max. 0.61 mm in thickness : min. 0.02 mm max. 0.23 mm.
LJB. 117	48 × 14 × 63	
G.B.M. 530 . . .	40 × 12.5 × 50	

IV. Lubricants.

In the bearings of the traction motors, T.2 lubricants are used, and in the bearings of the suspension of the motor, machinery oil.

V. Pantograph friction strips.

Strips of copper of 30 × 6 and 30 × 10 mm are used, fastened to the bow by means of a copper screw.

The admissible wear is that corresponding to a minimum thickness of 2 mm.

This wear corresponds to renewing the strips at approximately 30-day periods, i.e. 12 000 to 13 000 km.

[625 .6]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

17th SESSION (MADRID, 1958)

QUESTION 10.

In view of the development of light railways, what are the means to be adopted in order to reduce the operating costs of these railways and what are the resulting basic amendments ?

- **Delimitation of electrification and dieselisation in relation to the traffic, capital costs and operating costs.**
- **Co-ordination between rail and road.**
- **Possibilities of mixed rail-road vehicles and of specialised vehicles for rail or road.**
- **Principles to be followed in regard to investment, in order to improve the returns from the capital available for the transport industry.**

REPORT

(America (North and South), Australia (Commonwealth of), Burma, Ceylon, Egypt, India, Irak, Iran, Republic of Ireland, Japan, Malaysia, New Zealand, Norway, Pakistan, South Africa, Sudan, Sweden, Union of Soviet Socialist Republics, United Kingdom of Great Britain and Northern Ireland and dependent overseas territories),

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Based on replies from :

African Railways (East African, Sudan, Rhodesian, Nigerian & South African Railways);
Argentine Railways;
Burma Railways;
British Railways;
Ceylon Government Railways;
Eireann Railways;
Indian Railways;
Iraqi State Railways;
Iranian Railways;
Malayan Railways;
New Zealand Government Railways;
Swedish State Railways;
Tasmanian Railways;
U.S.S.R. Railways;
Victorian Railways.

* * *

FOREWORD.

A questionnaire was drawn up to elicit information on the various aspects of the above question. This was circulated to 34 railway administrations from whom at the time of compiling the report, only five fully detailed replies had been received.

One of the Railways sent its reply to a condensed questionnaire specially prepared.

* * *

INTRODUCTION.

As indicated in section I of the questionnaire it was rather difficult to define exactly the term « Light Railways ». It was, however, defined as a railway « which may be distinguished from a normal main line railway by its lower density, by its lighter trains and by the smaller axle loads running on it. Such a railway may have a certain importance from the economic or the political point of view but it is not dependent upon the profile, the gauge or the frequency of the train service ».

The East African Railways, the New Zealand Government Railways, the Malayan Railways, the Iraqi State Railways & the Burma Railways stated that they had no light railways. Both the Japanese and the Russian Railways stated that they had no clear demarcation between the normal lines and the so called light railways. The British Railways also did not operate nor have operated nor propose to operate any light railway in the future. The Association of American Railroads stated that in their country, in recent years, there has been a diminution of light or secondary railway lines, so the question of development of « light railways » was not applicable to the railways in their country. The Irish Railways had a few sections which could be classified as « light railways » but there was no development contemplated in the future. The Nigerian Railways had a section of 134 miles to a 2′-6″ gauge which could be classified as a « light railway ». This was soon going to be closed. A small branch (Narrow Gauge) line on the Sudan Railways, which was used for carrying seasonal cotton traffic had already been abandoned after a motor road had been provided.

The Indian Railways had included all their sections laid down to 2′ and 2′-6″ gauges in the categories of « light railways » because these sections carried lighter trains, smaller axle loads and lower traffic density.

The South African Railways were laid to 3′-6″ gauge and a lesser mileage to 2′ gauge. If the volume of the traffic carried was taken as a yard-stick, a fair number of the branch lines of the 3′-6″ gauge could also qualify as « light railways ». For the purpose of this questionnaire they have, however, included the narrow gauge sections only.

The Swedish State Railways included those lines in the definition of « light railways » which were not electrified or which were not expected to be electrified except, of course, certain non-electrified lines with relatively high traffic density. The « light railways », in this country, therefore, included a fair length of track laid to a gauge of 4′-8 ½″ besides some sections to smaller gauges.

In the Argentine Railways the appellation « light railways » could be applied to those railways which were constructed for the development of areas with very low population density and the other numerous branch line sections; but for the purpose of the questionnaire they included those branch lines which owing to their gauge or geographical location were isolated from the main lines. They had in their country certain branch lines under private ownership; they had been laid down to serve the industry but since sufficient technical and statistical data were not available, they had not been included when replying to the questionnaire.

The Victorian Railways had once five narrow gauge (2′-6″) sections of « light railways » in operation but now all of them have been abandoned excepting a length of about 34 miles which they are also proposing to close down. They do not envisage in the future construction of any light railway.

The information supplied by the reporting railways in reply to the questionnaire will now be presented in the form of questions and answers.

SECTION I.

GENERAL.

A. — Nomenclature.

Question 1. — *Do you call « light railways » by other names such as secondary, light traffic railway, etc.?*

The « light railways » in some countries are sometimes designated as secondary lines and in other countries such as Argentina as « improving railways meaning presumably « developmental railways ». Some countries classify their narrow gauge lines in general as « light railways ».

Question 2. — *Is it customary to make a distinction between such lines and the tramway lines?*

Yes. Tramway lines are worked under special regulations which are different from those for the working of railways. Such lines are usually owned by Municipalities and Corporations and are run in large cities for urban traffic.

B. — Situation.

Question 1. — *On your system what sections of lines are considered as « light railways »?*

Question 2. — *Supply if possible a map of these lines. Also show the other means of transport serving the same regions.*

These questions have been answered in the introduction to this report.

C. — Zones affected and aims.

Question 1. — *Give the agricultural, industrial or economic activities of the areas your « light railways » serve (population and areas served also to be given).*

Question 2. — *Or have the « light railways » been provided for development of the country or for strategic reasons?*

The « light railways » mainly serve agricultural areas and usually traverse sparsely populated parts of a country. On the Indian Railways some of them traverse mountainous regions and lead to hill stations serving as health resorts. In most cases, agriculture and exploitation of timber and forest produce along with some light allied industries are the chief pursuits of the communities living in areas served by the « light railways ».

In majority of cases the « light railways » were constructed with the aid of capital provided either by the State, private companies, or persons who were willing to invest their money. But in most cases the money was provided by the State partly for reasons of social and industrial development and in some cases for defence reasons or strategic purposes.

It had generally been observed that the effect of railways in development of undeveloped sections of a country was more marked during the later part of the 19th century and the beginning of the 20th century but it became increasingly weaker with the development of the modern road transport system.

D. — Development of the construction of the light railways.

Question 1. — *Give the data concerning the light railways:*

(a) *constructed during the last 20 years;*

(b) *under construction now or being planned.*

Question 2. — *For the line under construction or planned, give the technical characteristics (see infra) and the main reasons which warranted their construction.*

In no country who has replied to the questionnaire has any « light railway » been constructed during the last 20 years and in no case is any development envisaged for future. The only exception to this is Swedish State Railways who have at present under construction about 30 miles of a line for moving goods traffic.

In their case, the new « light railway » section will connect plants along the coast which have up to now not been connected with the present railway system and its

construction, therefore, was warranted for reasons of industrial and labour market policy. This line is being laid with old 87 lb. rails varying in length between 62 to 92 ft. and laid on wooden sleepers, 2 080 to 2 240 per mile, and with gravel ballast. The rails are secured to the sleepers by rail spikes. Minimum radius of curvature is about 2 000 ft. and the maximum gradient 1.7 per cent.

Question 3. — *If the new light railways proposed to be constructed are for developing the country or for strategic reasons, are they being laid to some lower specifications for track, bridges and equipment than that for your main lines?*

Question 4. — *What is the anticipated saving (percentage) in the capital cost by this modification?*

The Swedish line referred to above is being laid with lower standards for track and super-structure than for the main lines. This would produce a saving of about 25 % in the capital cost.

In general, all « light railways » were constructed to lower standards of construction than for their main lines with sharper curves, lighter rails and with lower axle loads. The saving in capital cost varied between 25 to 33 % of the cost of constructing a unit length of their main line.

Question 5. — *During the last twenty years has the working of any section of your light railways been simplified from the operating point of view or has any section been substituted by other modes of transport or abandonned?*

Question 6. — *Please show if possible, on a map such sections of the railways giving their mileage and the percentage in relation to the total mileage of the system. Indicate also the sections on which operation has been simplified, provided with other modes of transport or closed to traffic.*

The Swedish State Railways report considerable simplification in the routine working of the whole State railway net work including the « light railways ». On such lines in question, dieselization has been carried out to a great extent and the work of abandonment or reducing services on sections running at a loss has been intensified. Where rail traffic has been abandoned, the Swedish State Railways have as a rule arranged replacement services by road for passengers and small consignments.

The South African Railways report that where traffic did not justify a regular service, the passenger traffic was moved by road transport and goods traffic was carried by trains as and when required.

Reports of abandonment of the following « light railway » sections have been received :—

Name of Railway	Gauge	Length	Remarks
Nigerian Railways	2' 6"	134 miles	Not replaced by alternative transport facilities.
Sudan Railways.	Narrow Gauge	From Tokar to Trinkitat	Traffic carried by motor road.
Argentine Railways	Metre (3' 3 $^3/_8$")	About 50 miles	— do —
Swedish State Railways . .	Different gauges	About 430 miles	— do —
Victorian Railways (Australia)	2' 6"	84 miles	Adequate road services exist.

E. — Reasons for the simplification of operation.

Question 1. — *What are the technical and economic considerations which determined the simplification of the operation of these lines?*

Question 2. — *What simplifications in operation have been adopted or realized particularly in regard to the installations, staff, reduction of services, etc.?*

In most cases no simplification of the operation of the « light railways » was possible as the operating procedures were common to both the main lines as well as the « light railways ». In the case of the Swedish State Railways, a number of stations were closed, the time of opening of Ticket Offices and premises for the public were limited. In their case, the demand for security and satisfactory operation of trains, however, made it impossible to reduce the staff to the maximum limit possible or to carry out other economy measures to such an extent that the operation of the « light railways » could be profitable.

It would appear that other railway administrations also carried out steps as employed on the Swedish State Railways to operate « light railways » to achieve the highest possible economy.

F. — Reasons for substituting the lines.

Question 1. — *Is the carrying capacity of the light railways in your State at present less or greater than the traffic potential?*

Question 2. — *Have the railway services on the closed down lines been replaced by motor services (or possibly by trolleybus):*
(a) *for passengers and luggage?*
(b) *for parcels?*
(c) *for full wagon loads?*

Question 3. — *By whom are such services run? (in particular: by the railway itself or by other undertakings).*

Question 4. — *Have the substitute services been able to cope adequately with the railway traffic?*

And in particular, are the routes worked by these services sufficient to pick up all the railway traffic?

Question 5. — *Do you consider that the substitution of other modes of transport for the railway services has led to real economic advantages as regards the handling of traffic and in the general framework of the transport of the district?*

Question 6. — *Please state briefly the importance of such advantages, in particular the reduction in staff, if possible, the reduced operating costs, and the variation in output over a complete financial year.*

Question 7. — *State if the proposed substitution has caused difficulties or opposition from the public or the authorities, and how were these difficulties overcome.*

Question 8. — *Do you consider that the substitution has caused any inconvenience to the public subsequently? Explain in sufficient detail.*

Replies received from Railways indicate that the carrying capacity of the « light railways » was generally in excess of the traffic potential. Where the capacity was deficient as on some « light railway » sections on the South African Railways, the narrow gauge lines were being converted to a bigger gauge.

As a rule in cases where the « light railways » have been abandoned, the carriage of passengers, luggage and parcels has been taken over by the road transport. Full wagon loads are very rarely offered in such areas and their transport as a rule is arranged for by the forwarders themselves.

The replacement road services are run by public companies and in the case of the Swedish State Railways, the Railway also has a share in the running of the road services. Such services have been able to

cope adequately with all the traffic offered and have generally given satisfaction to all concerned.

The Swedish State Railways have reported that due to closing down of about 430 miles of their lines during the last few years, there has been a considerable net gain accruing to the Railways.

When a railway service is substituted by road transport, there is in the beginning a good deal of opposition from the communities who are served by such lines. In all cases the closing down of a railway line requires governmental sanction but before any line is closed, meetings are arranged with the representatives of the municipalities, rural communities, and at such public meetings it is possible to explain to them the railway's point of view and the reasons which would warrant closing down of any railway line.

Generally speaking, the abandonment of light railways has not caused any inconvenience to the public.

G. — Reasons for closing down the lines to traffic.

Question 1. — *What is the main criterion of a technical, economic or social nature, which determines the closing down of a line?*

Question 2. — *Please also give briefly the particular reasons which led to the line being closed down in those cases which you consider most important.*

Question 3. — *Indicate moreover if the proposal to close down the line gave rise to any difficulties or objections from the public or the authorities, and how such difficulties were overcome.*

The main considerations which normally dictate the closing down of a railway line are of an economic nature. Decreasing rail traffic due, in many cases, to keen road competition, rendered operation of such lines not only unprofitable but actually caused heavy losses. In come cases for reasons of defence or developmental policy of the Government, some rail sections with little traffic could not be closed down.

As has been mentioned under Section I (F) above, railway traffic is not usually closed without a replacement in the form of road transport. The public reactions to such closing down have already been indicated above.

SECTION II.

STATISTICAL DATA FOR THE LINES IN OPERATION.

Question 1. — *Please give the following data for each line or homogeneous group of lines (homogeneous as regards the system of traction, characteristics of the layout and profile, and volume of traffic).*

A. — Technical data.

(a) *Track, superstructure, buildings.*

1. — *Total mileage of the lines.*

2. — *Gauge.*

3. — *Rail section or profile.*

4. — *Weight per metre or yard of rail (prevailing).*

5. — *Minimum radius of curve and the prevailing degree of curvature.*

6. — *Maximum and prevailing gradients.*

7. — *Number of sleepers per kilometre or mile of track. (If longitudinal timbers or supports are used, it may be so stated).*

8. — *Length of rack railway lines.*

9. — *Other interesting data.*

10. — *Describe the maintenance methods and tools used to repair the tracks.*

Please see Appendix 1 for the above particulars.

(b) *Rolling stock and operation.*

Question 1. — *System of traction (steam, diesel, electric, mixed).*

Question 2. — *For each system of traction, please give :*

(1) *axle load, wheel arrangement, tare, capacity of the principal types of locomotives and motor coaches;*

(2) *if possible, the year of construction of the locomotives, motor coaches and freight wagons used;*

(3) *importance of the stock, percentage of utilisation of the various types of rolling stock;*

(4) *give a short descriptive note regarding the methods and tools for maintenance and repair of :*

(i) *the electric installations;*

(ii) *locomotives, coaches and wagons.*

Question 3. — *Are there any special features of maintenance of track and of wheel tyres, etc. (for example : grinding of the rails and of the tyres)?*

Please see Appendix 2 for reply to above questions.

Question 4. — *Describe the operating and signalling systems in vogue including the methods of marshalling goods trains.*

On the Argentine Railways the signalling is simple, i.e. in general hand-operated semaphores are used.

The signalling system on the Ceylon Government Railways is generally of a non-interlocked type with only one Up and one Down Home Signals operated by a two-lever ground frame situated near the Station Master's office and it is so designed that one lever locks the other. The points are secured by clips, padlocks and keys, the Station Master being personally responsible for the safe custody of the keys.

The Indian Railways have almost a similar arrangement. All the « light railways » are single line sections. Trains are worked on the absolute block system, though on some sections one-engine system is also in force. The authority to proceed is mainly a « line clear » ticket. Almost all stations on these sections are uninterlocked. Important stations have outer and home signals, whereas other stations are provided with only one stop signal and, in fact, some have no signal at all. Goods traffic is generally carried by mixed trains (passenger-cum-goods) and only on certain sections are goods trains run regularly. All these sections are connected with Broad Gauge or Metre Gauge sections. Goods trains are marshalled with loads for transhipment at break-of-gauge points separately and loads for other destinations grouped in station order.

The South African Railways report that owing to the paucity of traffic on the « light railway lines » mechanical signalling is not justified and control is entirely by hand signals.

On Swedish State Railways there is no special signalling system for « light railways ». Shunting is carried out with the train locomotive or with a special locomotive. There is no special equipment for shunting work.

Question 5. — *Did the question of availability of adequate feed water supply for loco purposes affect your decision on the mode of traction adopted?*

The Ceylon Government Railways and the South African Railways replied in the affirmative. The latter state that with the gauge conversion of the South-West African Narrow Gauge lines, diesel traction will replace steam engines.

The Swedish State Railways and the Indian Railways replied in the negative.

Question 6. — *Is electric traction being already used in your country? Which of the following forms of generation are adopted?*

(a) *Hydro-electric*

(b) *Thermal Plants*

(c) *Both thermal and hydro-electric sources.*

Question 7. — *In case of electric traction,*

(a) *What is the system of traction — A.C. or D.C.?*

(b) *If D.C., please state the voltage,*

(c) *If A.C., state the voltage and frequency: 15, 16 $^{2}/_{3}$, 25 cycles or industrial frequency.*

On the « light railways » electric traction is not being used as the conversion from steam to electric traction is not economically justified.

On Swedish State Railways although hydro-electric power is available, yet its use on « light railways » is not considered profitable. Instead, passenger traffic is in most cases carried by rail cars and goods traffic by diesel and steam locomotives.

Question 8. — *Give approximately the cost price of the various types of locomotives and motor coaches (steam, diesel or electric) at present day prices.*

Ceylon Government Railways.

The original price of the locomotives varies between 4 000 to 19 000 £ Sterling.

Indian Railways.

The cost price of the types of locomotives in use is given below :—

	£ Sterling.
(i) Steam locomotive ZB type	13 000
(ii) Steam locomotive 2-8-2 type.	21 000
(iii) Diesel hydraulic	20 000

South African Railways.

The cost of the Narrow Gauge steam locomotives placed in service in 1953 was about £19 000 each (South African currency).

Swedish State Railways.

The prices of locomotives and railcars are given below :—

	£ Sterling.
Steam locomotive	30 000
Diesel locomotive, between	29 000
and	73 000
Railcar	17 500

Question 9. — *Give some operating characteristics :*

(i) *speed, frequency, density of traffic, mileage between stops — composition of the trains (passenger and freight), number of stations per 100 km.*

(ii) *Percentage of stations with :*

(1) *full complement of operating staff;*

(2) *staff dealing only with the selling of tickets and booking of parcel and goods traffic;*

(3) *not staffed.*

Please see Appendix 3 for reply to this question.

B. — Economic data.

(a) *Receipts.*

Question 1. — *Please give in the form of a table the*

(i) *total of trains/kilometres or train miles;*

(ii) *gross receipts — receipts per km or mile and net receipts;*

(iii) *number of passengers carried;*

(iv) *number of passengers/kilometres or passenger-miles;*

(v) *passenger receipts — per passenger-km or mile and per line/km or mile;*

(vi) *weight in tons of freight carried;*

(vii) *freight tonnes/kilometres or ton-miles;*

(viii) *freight receipts — per km or mile of line and tonnes/km or ton-miles;*

(ix) *if possible, give the percentage of originating traffic to the total traffic over the railway.*

Most of the Railways who replied to the detailed questionnaire do not maintain separate statistics for the « light railways » and therefore have not given the figures asked for in this question.

The Indian Railways give the following figures for 1955-56 :—

(i) Total train miles in thousands	6 639
(ii) Gross earnings per mean route mile worked . £ Sterl.	1 053
(iii) Number of passengers carried, in thousands	3 356
(iv) Number of passenger miles, in thousands	697 856
(v) Passenger earnings per route mile . . . . . £ Sterling	577
(vi) Tons carried ,in thousands .	3 059
(vii) Net ton-miles, in thousands .	167 017
(viii) Goods earnings per route mile . . . . . £ Sterling	345
(ix) Percentage of tons originating to tons carried	41 to 90

(b) *Total expenditures.*

Question 1. — *Please give in the form of a table the operating expenditure per kilometre or mile, distinguishing between :*

(a) *fixed costs independent of the traffic (labour and materials for the maintenance of the line, installations and buildings, general operating costs and station supervision, as well as sinking fund charges for the fixed installations);*

(b) *dependent costs i.e. those depending upon the kind and volume of traffic (labour and materials for the services and traction);*

(c) *miscellaneous costs.*

The above costs should be given separately for labour (including insurance and welfare allocations), for materials and those under other headings.

The data under b) *can be given per km or mile of lines as well as per unit of traffic (train-km or mile or better still ton/kilometre or mile); in addition, for the costs under* b) *it should be made quite clear to what method of traction these refer; in the case of mixed services give the percentage of train-km (or ton/km or mile) worked with railcars, passenger trains and freight trains.*

(d) *If possible subdivide the costs still further under the following three headings : total labour costs, purely traction costs (power consumption and rolling stock maintenance) and miscellaneous costs;*

(e) *number of staff per km/mile of line and for the following categories :*
- *management and general services;*
- *maintenance and inspection of lines and installations;*
- *station traffic;*
- *travelling staff;*
- *engines;*
- *rolling stock depots and shops;*
- *miscellaneous.*

(f) *average cost including social charges.*

NOTE : The figures for costs may preferably be given in Swiss francs or in pounds sterling.

Most of the reporting Railways have not given any figures since they are not available. The Indian Railways have given the following figures for 1955-56 :—

	£ Sterling.
(i) Maintenance of structural works, in thousands	881
(ii) Maintenance and supply of locomotives, in thousands . .	1 328
(iii) Maintenance of Carriage & Wagon Stock, in thousands .	458
(iv) Expenses of Traffic Department, in thousands	635
(v) Expenses of General Department, in thousands	135
(vi) Miscellaneous expenses, in thousands	52

	£ Sterling.
(vii) Expenses of Electrical Department, in thousands	40
(viii) Expenses of Signal & Telecommunication Department, in thousands	43
(ix) Appropriation to Depreciation Reserve Fund, in thousands	418
(x) Total working expenses, in thousands	3 992
(xi) Working expenses per mean route mile per week	29

Question 2. — *Did you make during the last 10 years, or are you making at present for any lines about which you have given statistical data asked for in the previous question, important alterations as regards the installations and rolling stock?*

Question 3. — *Describe briefly the nature of any such work as regards the following principal points:*

(a) *replacing the superstructure (length in km or miles);*

(b) *electrification (length in km or miles, system, and number of substations);*

(c) *mechanisation of the points, signals and level crossings (length in km or miles or number of such equipment);*

(d) *new rolling stock (number of units) and principal characteristics).*

Question 4. — *Indicate on which lines you have carried out or are carrying out a partial or complete alteration of the method of traction.*

Note: By alterations being carried out, we mean those for which the necessary capital allocation of funds has already been made.

Most of the reporting Railways have made no important alterations recently as regards the installations, rolling stock and method of traction. The Ceylon Government Railways report provision of improved amenities for lower class passengers. The Indian Railways have introduced a few modern type steam locomotives and as an experiment on two sections, 8 diesel hydraulic locomotives. They do not report any radical change in the design of wagons and coaching stock. The South African Railways are converting some Narrow Gauge lines in South-West Africa to their 3′-6″ gauge and dieselising them. The Swedish State Railways report the introduction of latest types of normal gauge railcars with a seating capacity of 53 in the railcar and of 62 in the trailers. Trailers which carry goods traffic besides passengers have a seating capacity of 36 to 39.

Question 5. — *What are the costs of*

(a) *coals (qualities or grades available),*

(b) *liquid fuels,*

(c) *electricity (per unit at the substation).*

Question 6. — *Indicate the source and quantities in tons which can be easily obtained.*

(Please see table on next page.)

C. — Economic considerations.

Question 1. — *State the economic considerations and others which affected your choice of the system of traction for your:*

(a) *main lines;*

(b) *light railways, in relation with the density of traffic, capital expenditures and operating expenditures.*

When the railways were first constructed, all countries generally had the steam traction. Modifications in mode of traction were introduced later. Thus electrification of their main lines was found profitable by the Swedish State Railways.

The Ceylon Government Railways have now decided to adopt diesel traction on their main lines on account of the lower running cost, scarcity of water and need for better timing, though on the « light

Cost of fuel on « light railways »

(Figures approximate)

N.K. = Not known.

Name of Railway	Coal per ton	Liquid fuel per ton			Electricity per unit	Remarks regarding quantities available
		Furnace Oil	Fuel Oil	Diesel Oil		
1. *Ceylon Government Railways* .	£ 7.0	£ 9.1	£ 16.0	—	not used	Coal imported from India and oils from Middle East available as required.
2. *Indian Railways*.	£ 1.2 to 1.6 at pit head	—	—	£ 22.5	do	Coal available as required. Crude oil has to be imported.
3. *South African Railways* . . .	£ 0.6 to 0.8 at colliery siding	N.K.	N.K.	N.K.	do	Coal and oil available as required.
4. *Swedish State Railways* . . .	£ 7.6	£ 11.0	N.K.	£ 13.6	0.44 d per kwh	—

railways » they continue with the steam traction.

The Indian Railways because of the abundance of coal in the country carry the bulk of traffic on their main lines by steam locomotives. Electrification has been confined to the suburban services on the main lines and the congested trunk routes. Diesel traction is now being introduced on sections where water is scarce or where the cost of coal on account of long leads from the colliery goes up very high. Diesel hauled goods train services are also being introduced on main line sections which are subsequently going to be electrified.

With the South African Railways, the cheapness of the indigenous coal is the primary reason for steam traction. Where heavy density of train services, such as on suburban lines or on steep gradients, have made steam traction difficult, electrification has been introduced. On sections where water supplies constitute a problem dieselisation has been decided on. On « light railways » which serve areas of low traffic density steam traction continues.

The Swedish State Railways have found electrification highly profitable for their main line traction, though on their « light railways » the traffic volume is too small to justify electrification. The passenger traffic has been motorised and the goods traffic is hauled by diesel locomotives.

Question 2. — *Which of the following considerations, and to what extent, affected your decision for adoption of any particular system of traction :*

(a) *Indigenous capacity for manufacturing traction equipment, excluding locomotives.*

(b) *Indigenous capacity for manufacturing locomotives (steam, diesel or electric).*

(c) *Local availability of technical knowledge*
  (i) *for design,*
  (ii) *for manufacture of equipment.*

(d) *Local availability of fuel or of electric power at economical costs.*

It appears that on many railways factor (d) regarding the local availability of fuel at economical costs, was the major consideration in determining the system of traction. Since coal is cheaply and abundantly available on the Indian and South African Railways and easily importable by the Ceylon Government Railways, steam traction continues. The Swedish State Railways started with steam traction though subsequently for their main lines, electrification was found profitable.

Question 3. — *Do you design and execute your own traction projects or is the work carried out in collaboration with foreign consultants?*

On Ceylon Government Railways, projects are planned by the railway themselves and locomotives are imported according to their requirements.

The Indian Railways undertake their own traction projects and manufacture the steam locomotives as well as the coaches in their own country, though some are being imported.

On the South African Railways, their own engineers carry out the traction projects and the same applies to the Swedish State Railways.

SECTION III.

REHABILITATION PROGRAMME.

Question 1. — *Do you consider the present financial situation of the light railways of your country as satisfactory?*

All reporting railways are unanimous that the financial position of their « light railways » is far from satisfactory viewed purely as individual entities or as transport schemes but are regarded as essential to the economic development of the country as a whole.

The Swedish State Railways report that their light railways bring about an estimated annual loss of about 14 million pounds sterling; so also the Argentine Railways report heavy deficits.

Question 2. — *Can you improve the financial return by making alterations leading to an increase of the receipts or to a reduction of the operating expenses?*

The Argentine Railways see no hope of improvement owing to the lack of production in the areas served by the light railways and have no modifications in view of an alternative mode of traction or for operational improvements for these lines and this view is shared by the Victorian Railways.

The Ceylon Government Railways are strengthening their track and bridges on their light railways to enable heavier engines to run at faster speeds and thus hope to improve the financial position.

Although the light railways in India serve mainly agricultural areas or mountainous regions, yet in many cases road services provide alternative means of transport suitable particularly for short distance traffic. Therefore the Indian Railways do not see any possibility of a substantial increase in traffic receipts.

The South African Railways do not consider that the traffic at present justifies heavy expenditure on improvements but see a possibility of reducing the working expenses on the existing light railways.

The Swedish State Railways have been able to improve the financial return by adopting one or more of the following methods :—

(*a*) Lines with low volume of traffic are being closed down, wholly or in part.

(*b*) Certain stations are closed; others are unstaffed.

(*c*) Diesel traction replaces steam traction.

(*d*) Locomotive hauled trains are substituted by railcars.

To a greater or lesser extent, all the above measures have been adopted with a considerable measure of success. There have been improvements in the revenue earning capacities of some of the light railway sections.

Question 3. — *What measures do you think it would be possible to adopt to increase the receipts (for example by raising the rates or getting more traffic) apart from rail-road co-ordination?*

The scope for adoption of the commercial measures suggested in this question is small. The Ceylon Government Railways see a ray of hope in intensifying canvassing for traffic and by inaugurating a road feeder service. On the light railways in India, raising the rate for traffic is unthinkable as in many cases, the road services offer keen competition. Apart from this it must also be remembered that since these railways form a part of the rest of the Indian Railway system, there is a public criticism if the rates are enhanced. On some hill sections, charges were levied on enhanced mileages but recently the enhancements have been reduced over some sections by about 25 %.

On the South African Railways also, the rates applicable over light railways under the revised tariff structure are precisely the same as for similar traffic over their main lines. The areas served by the light railways have a strictly limited production capacity and the type of traffic cannot bear increased tariffs.

Question 4. — *What measures do you think could be taken to reduce running costs, apart from altering the method of traction or making other fundamental technical changes (for example, closing down stations, having maintenance work done by contract, simplifying the operating regulations, replacing certain services by motor transport, etc.)?*

The Ceylon Government Railways have reduced the running costs by such means as switching out stations during certain hours of the day, downgrading other stations or by manning them with lower categories of staff or by converting uneconomic stations to ticket agencies.

The Indian Railways see no possibility of an appreciable reduction in the operating costs on their light railways unless additional facilities for improved operations are provided; during the last ten years or so this has not been possible.

The Swedish State Railways have taken, as detailed in reply to Question 2 above, all the measures envisaged in this question with considerable success. Other reporting railways except the South African do not think it possible to devise measures to reduce the running costs.

Question 5. — *Do you consider it would be possible to obtain considerable reduction in the operating costs (or an increase in the receipts) by taking radical steps as regards the method of traction and the improvements to the installations and the rolling stock?*

Question 6. — *If so, for what lines in particular do you recommend changing over from steam traction to diesel traction? On which lines to electric traction and with what system?*

Question 7. — *On what criteria do you base your decision that electric traction would be better than diesel traction or vice versa:*

(a) *according to the comparative cost or availability of fuel or electricity?*

(b) *the volume, kind and distribution of the traffic;*

(c) *the characteristics of the layout and profile of the section;*

(d) *the comparative cost of buying the rolling stock;*

(e) *other reasons of local interest.*

Question 8. — *On which lines, and for what reasons, do you think it would be better to retain steam traction wholly or partly?*

The Ceylon Government Railways consi-

der that by dieselisation, reduction in operating expenses is possible but at present, dieselisation is being started on their main lines only.

The Indian Railways agree with the above view that some reduction in operating expenses can accrue if the method of traction is changed or improvements to installations and rolling stock are effected but not much increase in the traffic receipts is expected on this account. Though some diesel locos have been introduced as an experimental measures on some light railways, there is at present no proposal to dieselise completely any section of a light railway.

The South African Railways have recently introduced some diesels on their main lines but are not optimistic about reducing the operating costs of their light railways by dieselisation.

The Swedish State Railways consider that running costs can be drastically reduced by complete dieselisation. As already stated elsewhere, their passenger services have been motorised by use of railcars and goods service partially dieselised on some sections. The rate at which goods traffic can be entirely dieselised depends on the financial situation, availability of capital and on the possibilities that there are for other profitable or pressing investments.

No railway administration considers electrification of their light railways justified in view of the low traffic densities offering: dieselisation in such cases is preferred to electrification though this has its limitations in countries like India and South Africa where indigenous coal is generally cheap and oil has to be imported.

The South African Railways opine that on easy gradients and on lines where traffic potential is less than the line capacity, the retention of steam traction is justified. As against this the Swedish State Railways consider that only in a few cases, steam traction should be retained.

Question 9. — *What saving do you expect to obtain by substituting diesel traction completely (or merely for the passenger services) for the steam traction?*

In view of what has been stated in the reply to the above questions, this proposition does not arise for most of the reporting railways.

The Swedish State Railways estimate an approximate annual saving of about one million pounds sterling if steam traction is entirely replaced by diesel traction but the investment capital required would be of the order of about 7 million pounds.

Question 10. — *Please indicate, according to your estimates, or better still according to the results obtained on lines recently converted by complete replacement of steam traction by diesel traction.*

(a) *reduction in the number of staff and cost per km/mile of line or train-km/mile;*
(b) *the reduction in the tare per seat in passenger trains;*
(c) *the reduced traction costs (train-km or mile) purely;*
(d) *any other reductions in the operating costs;*
(e) *the reduction in the number of power units (locomotives, motor coaches and other rolling stock).*

The Swedish State Railways have given the following estimates of saving by dieselisation :—

(*a*) An estimated saving of about 250 persons would be made with dieselisation with an estimated reduction of about £27,000 in staff expenses per annum.
(*b*) A reduction of about 0.125 tons in the tare per passenger seat (weight of the locomotive has not been included in the estimates).
(*c*) A reduction of approx. 0.27 million pounds sterling in fuel costs per annum.
(*d*) Track maintenance costs would be lower as a result of the reduced train weights.
(*e*) Approximately 130 fewer locomotive units would be required.

Question 11. — *Please indicate, according to your estimates, or better still according to the results obtained on lines recently converted to electric traction.*

(a) *the reduction in the number of staff and cost per km of line or train-km;*

(b) *the reduction in the tare per seat in passenger trains;*

(c) *the reduction of traction costs (train-km or mile) purely;*

(d) *any other reductions in the operating costs;*

(e) *the reduction in the number of power units (locomotives, motor coaches and other rolling stock);*

(f) *increase of costs of maintenance of the line and fixed installations (sub-stations).*

None of the lights railways has anywhere been electrified.

Question 12. — *At what figure do you put the increase in the financial charges due to the new rolling stock (diesel or electric) as well as for the line improvements and electrical installations?*

The Swedish State Railways estimate that the costs for interest and amortisation at 6 % rate of interest from purchases of new rolling stock would be about half a million pounds sterling.

The South African Railways give the following figures of cost of conversion from steam to electric traction.

	Single line £	*Double line* £
(i) Overhead equipment per mile	7 000	12 000
(ii) Substations	8 000	8 000
(iii) Electric units	17 000	17 000
Total :	32 000	37 000

Question 13. — *Give as far as possible separate figures per km or mile of line and ton/km or mile (or train-km/mile) specifying the period of amortisation and the rate of interest.*

How do you propose to meet these increased financial charges? (In particular by the expected operating economies or by subsidies from the State.)

No figures have been given by any railway.

Question 14. — *For which lines, on the contrary, do you consider any such measures would be useless, so that in the near future they will have to be entirely closed or replaced by road services?*

Question 15. — *In spite of the impossibility of financial rehabilitation, what other line have you to keep for reasons other than economic ones?*

In reply to questions I D 5 & 6 details of light railways already closed have been given. Besides the Swedish State Railways and the Victorian Railways, others have no proposals for closing of their light railways. The Swedish State Railways have at present applied for Government sanction for closing wholly or in part about 85 miles of their light railways. Within the next few years, they propose to investigate closing down of another about 600 miles. The Victorian Railways are going to close down the only remaining section of about 34 miles of their light railways.

Question 16. — *In order to reduce the general costs, did you consider the possibility of amalgamating the light railways with other railways in your country or state?*

In the case of all the reporting railways except the Swedish State Railways, the light railways sections are already a part of the railway system in their countries.

In case of Sweden, there are some light railways under private management. Their

nationalisation was at one stage mooted but prospects of improving their financial condition did not appear to be bright.

SECTION IV.

RAIL-ROAD COORDINATION.

Question 1. — *Describe other-than-rail transport facilities available in the areas served by the light railways.*

All the reporting railways have indicated that road services exist. In India in most of the areas served by the light railways, road transport by cars, buses and lorries is available though over short distances goods traffic also moves by means of bullock carts.

The South African Railways report that they themselves are the largest road transport operators in the country. But their road transport service is coordinated with the rail services to which such road services act as feeders.

In Sweden, in areas served only by secondary lines, there is as a rule access to country-line buses run by the private companies or the State Railway for the transport of passengers and parcels; commercial truck transport provides for the heavier type of goods.

Question 2. — *Do the light railway lines of your system suffer serious competition from road services operated by others, in particular :*

(a) *from bus services (passenger) partly or wholly parallel to the railway;*

(b) *from freight transport carried by long distance lorry services;*

(c) *from light private motor vehicles?*

(*a*) In Ceylon and India (except on a few hilly sections where there is no hill road) there is generally a keen motor competition from passenger bus services running parallel to the light railways. In South Africa it is normally not the policy to operate the road transport service parallel to the rail services except in certain areas where road transport to supplement the rail facilities is provided. This is applicable predominantly to passenger services in cases such as the following :

(i) where rail journeys are slow and acceleration is not possible,

(ii) where rail routes are circuitous and the time taken by journeys by rail is much longer than that by road.

In Sweden the large number of private cars offer a very serious competition to passenger traffic; there being a car for every 8 people in the country.

(*b*) In Ceylon, India and Sweden the lorry services offer very keen competition particularly as regards goods of high value and for short distance hauls, in Sweden up to as much as 125 miles.

Arising from the difficulties experienced by the South African Railways to meet all transport requirements in recent years, certain commodities such as house-hold furniture, coal, livestock, grains, fruits, vegetables, etc., have temporarily been allowed to be conveyed by road and in this respect they suffer serious competition from private road hauliers.

On the Victorian Railways government regulations permit a certain portion of the traffic offering, particularly of perishable goods and livestock, to move by road.

(*c*) Serious competition from light private motor vehicles has been experienced on almost all the reporting railways.

Question 3. — *What is your estimate of the traffic captured by the road? Indicate, if possible, the amount of traffic lost, and if the eventual return of such traffic to the railway is possible with the present rehabilitation schemes with consequent improvements in the operating results.*

As a rough estimate, the Ceylon Government & Indian Railways carry only about 50 % of the total traffic, the other 50 % being carried by the road services. On account of well known advantages that the

road transport has to offer for short distance traffic, it is unlikely on the Indian light railways that the proportion of traffic carried by the railway would improve in the near future. The Ceylon Govt. Railways are strengthening the track structure on their light railways to the standard of the main line and thereby expecting to accelerate their rail services with the hope that a good proportion of the traffic at present lost to road would eventually return to them.

In the case of South African Railways as already stated their difficulties are of a temporary nature and if at some future date they are in a position to cope with all the traffic offering, that carried by road at present will be returned to rail. They are, however, unable to give an estimate of the traffic that has been lost to them.

The Swedish State Railways show how the passenger journeys by rail have declined by about 18 % in the six years from 1949 to 1955. Although the goods traffic carried by rail has increased during these years, the percentage increase in freight traffic carried by road is more than that on the railway as shown by the following figures, taking 1949 as the base year :—

Development of Goods Traffic

	Carried by Railway	*Carried by Road*
1949	100	100
1950	109	109
1951	127	123
1952	119	137
1953	110	151
1954	119	173
1955	132	189

The decrease in goods traffic has been more marked for distances from 60 to 125 miles.

Question 4. — *Is your railway managed by*

(a) *the State or*

(b) *public or private companies?*

Who owns and operates your road services?

In Ceylon, the railways are owned and managed by the State, there being no public or private companies. In India, the railways are owned by the Government and so is the case in South Africa and on the Victorian Railways.

As regards the Swedish State Railways, the position at the end of the year 1956 was as follows :—

	Normal Gauge *(Miles)*	Narrow Gauge *(Miles)*	Total *(Miles)*
(i) Owned by the State	7 742	1 541	9 283
(ii) State owned but run in form of Company	—	179	179
(iii) Private Railways (9 companies)	368	171	539
	8 110	1 891	10 001

In Ceylon road services are operated by private agencies on tender system.

In India as regards the road services, the freight services are mostly private owned and privately operated. There are a few public companies operating road services for freight traffic. In regard to passenger services, there are three types of organizations :

(i) In some of the States, passenger services are run by road transport corporations which are jointly owned by the Central and the State Governments. Major portion of the capital is provided by the State government concerned.

(ii) In some other States, the passenger services are owned and operated by the State Governments departmentally.

(iii) In other States most of the passenger services are privately owned and privately operated. The policy is, however, for the gradual nationalization of such passenger transport services to be run through State road corporations.

In South Africa the Railways operate their own road transport services for the conveyance of all classes of traffic, including abnormal loads. Minor passenger and safari services are provided by private companies.

In Sweden, the road transport is run both by the State and private companies, the Railway having a minor share.

In the areas served by the Victorian Railways, the road services are owned by private operators and the Railway Department is not associated in any way with the management of the road transport.

Question 5. — *Is your railway associated with the management of road transport? If so, give details.*

As mentioned above, in India, some of the States who have formed road corporations are allowing the railways to be one of the partners. This policy is being gradually extended to the other States.

In South Africa the railways themselves own most of the road transport system.

The Swedish State Railways run road transport partly by themselves and partly through three subsidiary companies, all the shares of which are owned by the railway. The railway road services deal mainly with the country bus traffic and with some lorry traffic to complement the bus lines. One of the subsidiary companies deals only with lorry traffic and the remaining two companies run both bus and lorry traffic.

Question 6. — *What special statutory facilities do the road services enjoy and what additional facilities do they render to their users in addition to those afforded by the railways? Are there any plans for rail-road coordination?*

In Ceylon and in India the road services do not have to pay towards the cost of construction and maintenance of roads except some road tax and tax on petrol. They have no other statutory facility. They are, of course, in a position to afford door to door service. This is not possible, in most cases, on railways.

The road services being owned by the South African Railways enjoy the privilege of exemption from taxation such as licence fees upon the vehicles operated by them and also from imposts such as excise duty on tyres and fuel and import duty on vehicles and parts thereof. For these concessions the railway administration pays a substantial voluntary annual contribution towards the cost of road construction to the authorities concerned. Some other statutory privileges are also accorded to the road services run by the railway administration though they are also enjoyed by some other private bodies owning transportation.

Legislation in Sweden governing road transport allows the transport company to adjust its tariff and standardise the services to suit individual requirements. This freedom is only limited by set maximum charges which, however, are relatively high. As a result of not being governed by any definite transport obligations, road transport undertakings are free to choose between various kinds of transport work and thus carry away the cream of traffic particularly the goods traffic which is high-rated, heavy, regular and which is well balanced in either direction. Even non-commercial road transport owned by various agricultural interests and industrial enterprises are able to exercise a certain amount of selectivity in the transport of goods, thus leaving only unfavourable transport assignment to the Railways. Because of the transport obligations and tariff restrictions, the railways are forced to deal with the transport which is considered unprofitable by the road transport companies such as bulk or seasonal peak transport, badly balanced transport as regards return journeys or transport of goods which are of low value or difficult to handle.

With regard to plans for rail-road coordination on Indian Railways, reference

should be made to the reply to the question above. These plans embrace running of passenger services through corporations formed jointly by the State Governments and the Railways. Apart from this a large number of out-agencies have also been opened at places which are away from the railway lines to afford to the merchants direct booking facilities for transport over both the rail and road journeys.

In South Africa, the internal coordination by the administration of road and rail services, of course, presents no problem and is in fact exploited as far as possible. Mention may be made of the fact that as a temporary expedient the administration is at present operating what are usually described as ancillary road services. These are intended to alleviate shortage of goods wagons which arose during the last war and which has not yet been fully eliminated and also the congestion occasioned by the backlog in construction works. This service is exclusively a goods service and conveys goods tendered to the administration in the first instance for conveyance by rail at railway rates. It is left to the administration to decide whether goods tendered for transport on the sections where such services are in operation should be conveyed by their rail service or by the ancillary services. These services will be discontinued as soon as sufficient rolling stock is available and construction works have been brought up to date but present indications are that it will not be possible for another 2 or 3 years. As regards coordination of services operated by private individuals or companies with those of the railway, statutory facilities exist. While, therefore, there is no universal plan of coordination in operation or pending at present, no opportunity is lost for effecting coordination of services wherever possible.

In Sweden steps are being taken to arrange for some rail-road coordination. On the Victorian Railways the road transport is controlled by Government regulations. These divide the available traffic between rail and the road to a certain extent.

Question 7. — *Do you think that any steps could be taken to reduce the harmful effects of road competition within the general framework of the country's transport (for example, limiting road services by government action, agreements with road hauliers, operating competitive services yourself or by contract)?*

The Ceylon Government Railways suggest governmental action for limiting road services and for having an agreed control on road hauliers.

In India it is considered that the inherent advantages of road transport are confined to short distance travel. Therefore, where an orderly development of both forms of transport can be organised, it appears desirable to limit the action of road services in spheres where they provide the most economical mode of transport. Ultimately it is to the national advantage that a particular means of transport is confined to a sphere where it is cheaper both from the point of view of provision of initial capital and also in regard to the running costs. In judging the situation, of course, all items of expenditure such as maintenance of roads and capital investment required for construction of better and wider roads with adequate bridging, must be taken into account.

The South African Railways consider that it is doubtful that with the present concessions for railway owned road transport services, further governmental interference with the purpose of eliminating competition would be possible.

In Sweden the Government is drawing up guiding principles for future rail-road traffic policy. The basic principles for this work are that legislation governing rail and road transport activities should be amended so that it better corresponds to the present stage of development of both these facilities and that competition on more equitable terms should be achieved.

The Victorian Railways are constantly appealing to the government for greater restrictions to be imposed on the road services. They also bring to the notice of

the government unauthorised movements against government regulations. The government is also considering the question of enhancing adequately the taxes on the road service operators.

Question 8. — *For the sake of comparison give the average rates per km or mile (passenger and freight) for the road and railway services.*

Question 9. — *Also give* if possible *the cost per passenger seat-km or mile (seated or standing) on the main types of buses, as well as the cost per seat-km or mile (traction and running costs only) for the principal types of railway service (steam, diesel or electric trains and railcars). Similarly, if possible, for the ton/km or mile of freight service.*

The Ceylon Government Railways give the following figures about the average rates per mile for transport of passenger and freight traffic by rail and road services :—

(i) *Rail Services.*

	Passenger per mile in pence (d)			Freight per ton mile in pence (d)							
	1st Class	2nd Class	3rd Class	1	2	3	4	5	6	7	8
Plain Sections	2.16	1.44	.72	2.25	3.15	3.82	4.14	5.04	5.94	7.11	10.8
Hilly Sections	2.88	1.8	.72	3.37	4.27	5.17	5.58	6.62	8.02	10.71	14.4

(ii) *Road Services.*

Plain Sections	Average .72 d.	9 d. inter-out-agency traffic 9.9 d.
Hilly Sections	Average .9 d.	10.8 d. inter-out-agency traffic 11.7 d.

The Indian Railways state that the average fare charged by a road transport per passenger varies from .56 d. to 1 d. per mile in different areas. The average rate charged for freight is not readily ascertainable as freight services are mostly operated by private carriers who do not have any fixed tariffs.

The average rate charged by the railways per passenger per mile is roughly .47 d. and for freight traffic between 1 d. to 1.1 d. per ton per mile. In some of the hilly sections, however, charges are levied on an enhanced mileage basis.

Other reporting railways do not provide any comparative figures for transport of passenger and goods by rail or road services.

Question 10. — *What steps do you think could be taken to improve your passenger services to fight road competition (for example by increasing the average speed, comfort conditions in trains and frequency and convenience of the train schedules, by providing transport between the station and the town or by the use of diesel railcars)?*

The Ceylon Government Railways consider that steps should be taken to increase speed, provide better passenger amenities and more frequent services well coordinated with the road services. The Indian Railways are of the opinion that the main competition between rail and road for passenger services is mostly for short

distance journeys where consideration of comfort do not weigh very much, the main considerations being cost, convenience of the train schedules and the speed of service. Under the present conditions on Indian Railways the traffic offering for most of the sections is sufficient both for the railway services available as well as for the road transport. Therefore, broadly speaking, there is no necessity of thinking of reducing passenger rates for combating motor competition. In view of the overall shortage of available rail transport in the country, the general policy at present is not to take any special steps for diverting passenger traffic from road to rail except in very exceptional cases where but for such action train services which would have to be run for other reasons will go without a proper load.

The Swedish State Railways are carrying out most of the steps mentioned in the question for improving passenger services. Thus by introducing rail-cars the average speed has been increased. The standard of comfort in them has been improved by better seating accommodation, etc.

Question 11. — *What steps do you propose to take, or have already taken to fight competition of road freight services? In particular:*

(a) *Services for collecting goods from the consignor.*

(b) *Special methods (road trucks or similar) for transporting full loads to clients premises.*

(c) *Containers, and of what type?*

(d) *Methods for the rapid loading in bulk of special freight (cement, coal, minerals, etc.) and whether such methods lend themselves to door to door transport?*

(e) *Other methods.*

In Ceylon the railways provide collection and delivery services in important towns and these facilities are being gradually increased. The use of containers has not yet been started.

In India, it has been generally found that any collection service to and from the stations provided by the railway would not work out cheaper to the merchants than the arrangements made by themselves. Consequently such action would not help in diverting road traffic to rail. The railways have no experience of working with containers as the general industrial development has not reached a stage where full use could be made of them. In case of transport of commodities such as coal, cement and minerals which move in bulk, the road transport has not offered any keen competition as they are ordinarily not capable of handling these low rated commodities. As stated in reply to the last question the present position in India is that there is an overall shortage of rail transport; consequently it is not the intention to take any steps for diverting traffic from road to rail. In fact as a short term measure, the railway would welcome road transport carrying the traffic which they are not able to carry themselves.

The South African Railways have introduced a mobile container service similar to the « piggy bag cars » so popular in the U.S.A. with the essential difference that the local vehicles are owned by the railway and are transported on existing steel railway trucks instead of specially constructed trucks as in the U.S.A.

The Swedish State Railways have already adopted all the measures listed in the question. In addition, they have started a campaign to increase the use of pallets.

Question 12. — *What is your experience of these services if they are already working?*

The specialised services wherever provided in Ceylon have been working satisfactorily. None has been provided in India. On the South African Railways the use of containers has been much appreciated by the trading community. The Swedish State Railways report that their experience with these facilities has generally been favourable and further that traffic with large containers is still in an experimental stage.

Question 13. — *Are most of your clients linked up with the railway by special sidings?*

The Ceylon Government and the Indian Railways report that assisted sidings have been provided to their important clients with large factories and manufacturing units. A majority of the clients are not yet linked with the railway by special sidings.

In Sweden there are about 800 special sidings for use by the industry and it is estimated that about two thirds of their goods wagons are loaded and unloaded at these sidings.

Question 14. — *Have you any plans for using road vehicles for carrying smalls to and from way-side stations and from and to important goods collection depots on the railway in order to improve the turn-round of wagons and shunting services?*

There are no such plans under contemplation at present both in Ceylon and in India.

On the Swedish State Railways on certain lines, local goods trains have been replaced for the past 10 years by zonal truck services. In a number of larger districts, goods are transported by lorries from the collection depots to the larger stations with the wagon service.

Question 15. — *Do you think it would be opportune to simplify radically your relations with clients for the freight services (for example simplification of transport documents, simplification of the tariffs and the making of special contracts for individual transport, simplification of methods of payment, etc.)?*

The Ceylon Government Railways are not in favour of simplifying the transport documents. In India, the scope for simplification of transport documents, etc., is not very great. In view of the large distances to be covered and also of the numerous handlings that are often necessary enroute, careful documentation is unavoidable. The Indian Railways have already taken considerable steps to minimise the complicated features of the railway tariff. On the whole, the tarrifs in force at present are fairly simple and straightforward and there does not seem to be much scope for further simplification, as a means of attracting more traffic to the railways. In regard to the making of special contracts, such action is legally prohibited under the Indian Railways' Act. There is, therefore, at present no move to modify this position.

The Swedish State Railways have also been paying attention to the simplification proposals since 1948 when a Railway Tariff Committee appointed by the government put forward a proposal for drawing up a new scale of charges for transport of goods. This included fixing the tariff for freights in wagon loads systematically and simplifying the tariff system so that the number of tariff combinations is considerably reduced. The Committee also proposed revised tariff for parcels and simplified freight rates.

Question 16. — *In particular do you consider it useful to set up agencies, managed by the railway or by a third party, acting as intermediary between the railway and its clients for complete door to door services?*

The Ceylon Government Railways consider that agencies managed by a third party would be more economical. This view is not shared by the Indian Railways who think that any intermediary between the railway and the client as proposed would not help in promoting railway traffic.

The Swedish State Railways opine that agencies of this kind may possibly be of value in certain instances where traffic is of sufficient magnitude.

SECTION V.

PRINCIPLES OF INVESTMENT IN THE TRANSPORT INDUSTRY.

Question 1. — *In your country, what are the sources of capital for developing*

(i) *rail transport;*

(ii) *road transport?*

Question 2. — *In your country is the investment in road and rail transport the concern of the same authority or of a different authority?*

Question 3. — *Is there in fact co-ordination between the investments in the two fields?*

Question 4. — *What are the principles adopted by your Government for the development of various forms of land-surface transport and how does it apply these principles?*

These questions have, to a large extent, been dealt with in the previous section (Section IV).

On the Argentine Railways, the railway transportation is provided by the State whereas the road transportation is generally provided by private investors although the roads are constructed by the State. The inter-provincial transport by rail and road is under the Ministry of Transport. The road transport through towns is provided by corporations and municipalities and that between different towns by the provincial authorities. The construction of roads is also under the authority of provincial governments.

In Ceylon, the government finds the cost for rail construction while the road transport has, hitherto, been provided by private enterprise. The nationalisation of road transport is in hand with the object of providing the much needed rail-road co-ordination.

In India, rail transport is provided by the government and so also the capital required for it. In regard to the road transport, passenger road transport in some of the States has been nationalised and is either run departmentally by the State concerned or through State road corporations in which the State government and the Central government are partners. In such cases, the required capital is found, in the agreed proportions by the State Government and the Central Government. Goods transport is mostly operated by private owners and they, therefore, find the required capital from their own means. Public limited companies for running road organisations are not very many in this country.

The overall investment in India at present is governed by the provisions made in the five year plans which make specific provisions for investment both in regard to road and rail constructions. To this extent the investment in the two fields is co-ordinated.

The importance of developing in India all the means of transport such as road transport, inland water transport and also coastal sea transport, in addition to the rail transport, is fully recognised. Broadly speaking, it is the aim to ensure that each one of these forms is developed within the sphere for which it is best suited economically. At present a limiting factor really is the availability of the capital for the necessary expansion and it has to be allocated in an order of priority taking into account the developments that have been projected. The Government has set up committees to go into the question of rail-sea co-ordination and the question of development of inland waterways. The Ministry of Transport of the Government of India specially looks after the question of balanced development of transport throughout the country. This Ministry is independent of the Ministry of Railways.

As mentioned in the previous section, most of the road transport belongs to the South African Railways and there the capital for both rail construction and for providing road transport is provided by the State. There are a few private transport owners who find their own capital for the purpose.

In Sweden, for railway construction and expansion works funds are found from the state railways' own appropriations to the depreciation account as far as these go and are otherwise financed by grants from the State. Road development necessitated by increasing traffic is financed by the taxation of motor vehicles and fuel. In towns money is found from the municipal or from special grants from the Government. Investment in motor vehicles is financed

by the various companies and private persons who own lorries, buses or cars. Co-ordination between the investments in the two fields is carried out by the two authorities i.e., the State Railway Board and the State Road & Waterway Board. Regional co-ordination of investments in these spheres only occurs in special cases as, for instance, in the traffic regions surrounding large towns and in connection with planning to close down some secondary railway lines.

At present there are, in Sweden, no set principles for the development of various forms of land surface transport. A committee is going into the question and will make proposals for principles which should control such development.

Question 5. — *If in your country there is a tendency to replace some sections of the light railways by road motor services, state whether the road policy is directed towards the development of a net work of road development intended to pick up the traffic in place of the railway.*

The proposal in regard to substitution of light railways by road motor service has already been dealt with in section I F & I G. In almost all cases when a railway line is closed, the traffic has been taken up by the road transport service.

In Ceylon and in India there is no intention of replacing any of the light railways by road services.

In Sweden, before the railway lines are closed to traffic the road authorities are informed in view of the fact that heavier road transport may be expected.

In almost all countries prior sanction of the Central Government is required before any railway line is closed. The State and local authorities are generally consulted by the Central Government before according the sanction.

Question 6. — *Is it possible for you to give some information on the investment in operating cost of the road transport services and railway service for different conditions (terrain, gauge, length of the line, passenger kilometre or mile per day, tons kilometre or mile per day)?*

None of the reporting railways has found it possible to give any figures.

SUMMARY.

GENERAL.

The *light railways* were constructed towards the end of the 19th and in the beginning of the 20th century essentially for the purposes of development of under-developed and sparsely populated regions of a country with a view to exploiting their agricultural, forest and mineral wealth. In some countries the *light railways* had some importance from the political point of view or served strategic purposes.

The *light railways* in some countries are called secondary or tertiary lines or even « developmental » or « improving » railways. They are, however, distinguishable from the tramways which provide transport in urban areas and which are generally worked under different State regulations.

With the exception of Sweden where a light railway section of about 30 miles is being laid, no other country has reported the construction of a light railway during the last twenty years. This section is being constructed to somewhat lower specifications than those for the main lines. This feature in general applies to all light railways ever laid down. The saving in the invested capital has, thereby, been of the order of about 20 to 30 per cent. With the advent of the modern road transport system which offered severe competition, the traffic carried by the light railways has generally been declining rapidly. In many cases some sections had to be closed down. Reports of actual or proposed abandonment of about 2,000 miles have been received from some of the railway administrations who sent detailed information on the subject. This alternative was forced on them as in most cases no simplification of the operation and improvement of the financial position was feasible, though all possible steps had been taken to reduce the operat-

ing costs and to achieve the highest possible economy. Generally the carrying capacity of the light railways is in excess of the traffic potential. Where this was not so, the section is strengthened and raised to the standard of a main line.

Whenever a light railway was closed down its work was taken over by adequate road services. The abandonment of the light railways brought about indirect financial gains as it tended to reduce heavy deficits and losses caused annually by their operation. In all countries the closing of a railway line required the sanction of the Government and before this was accorded the abandonment scheme was carefully considered in consultation with all the interests involved. Though in the beginning the closing of a railway line evoked public criticism and such proposals were met with great deal of resentment and opposition, yet all this was short lived. Soon the public discovered that the substitute road services carried out all the traffic satisfactorily and, by and large, no inconvenience was caused to the communities who were previously served by the light railway.

STATISTICAL DATA FOR THE LINES IN OPERATION.

From the detailed reports received it appears that about 10,000 miles of light railways laid down to all gauges ranging from 2′ to 5′-6″ are in operation. In fact, the actual mileage of the light railways may be far higher mainly due to the fact that all railways had not supplied the information and in quite many cases the railways had no definite rules for distinguishing between their main lines and light railway sections.

The track structure of the light railways is generally lighter involving the use of flat footed rails ranging from 24 to 50 lb per yd. for the narrow gauge sections to 80 lb for the broader gauges. The lines are laid with sleeper densities ranging from 2 000 to 2 600 per mile and have sharp curves and generally steep gradients (except of course, in plain sections), though not requiring the use of a rack and pinion. Maintenance of the light railways is by manual labour and no mechanical appliances are in use.

On the light railways, the mode of traction is by steam locomotives with light axle loads weighing between 4 to 9 tons on narrower gauges (2′ or 2′ 6″) and 11 to 16 tons on broader gauges (4′ 8 1/2″ or 5′ 6″). Quite often these locomotives are those which had been previously in use on the main lines and for this reason many of them are quite old. Here and there a few diesel locomotives have been introduced on the light railways as also railcars on some sections. In Sweden the passenger services have been motorised by the use of railcars and the goods traffic is worked by diesel or steam locomotives.

The signalling system on light railways is simple; in general hand-operated semaphores are in use. A station may have only one stop signal at its each approach and, in fact, some stations cannot boast of any signal, whatsoever. Almost all stations on light railways where signals are provided are non interlocked. Trains are worked generally on the absolute block system with « line clear » paper tickets, though on some sections one-engine system is in vogue. Traffic is generally carried in mixed trains carrying both passengers and goods. On some of the light railways in South Africa the passengers are carried by road buses belonging to the railways and the goods trains are run as and when required.

Most of the reporting railways do not maintain separate operating statistics as also for the working expenses for their light railway sections to enable a comparison being made of their performance in different countries.

None of the railways has reported any important alterations having been made during the last ten years to the installations and the rolling stock on their light railways. The only exception is perhaps the Ceylon Government Railways who are strengthening the track structure of their light railways to enable heavier engines to run on them at faster speed. There is no

report of any radical change in the design of wagons and the coaching stock. Only the Swedish State Railways have introduced the latest type of standard gauge railcars with improved seating accommodation.

No light railway has in any country been converted to electric traction as the low traffic potential does not warrant the heavy initial outlay involved in electrification. When the railways were first constructed, all countries generally had the steam traction and this mode continues on the light railways except in Sweden or as an experimental measure in India where diesel traction has been partially introduced. As most of the reporting railways have abundant supplies of coal at competitive rates and oil has to be imported, steam traction has continued. Further, this saves the heavy outlay of capital required for dieselisation.

REHABILITATION PROGRAMME.

The financial position of the light railways is, in general, far from satisfactory. Viewed purely as a transport scheme, their existence cannot be justified though they are essential to the economic development of the region they serve. The Railways have taken all practical steps to reduce the working expenses and thus cut down their losses. In many cases there are no possibilities of operational improvements unless radical alterations are made to the mode of traction and railcars and improved type of stock are provided. As this investment is not considered justified, the deficits in working have been reduced by abandoning the lines with low density of traffic either wholly or in part; by closing, during a part of the day or in entirety, certain stations whereas others have been unstaffed and by using light railcars for passenger traffic. The raising of tariffs to increase the receipts is generally not practicable as, first, the road services offer keen competition and secondly, such a step evokes strong public resentment. In South Africa the goods traffic is carried by goods trains or by the road vehicles owned by the railway at railway rates, there being not much competition offered by private bodies.

Dieselisation is in its infancy on the main lines of many reporting railways but it is unlikely that any of the light railways will be completely dieselised in the near future and this in spite of the fact that some of the administrations believe that the operating expenses can be drastically reduced by complete dieselisation. This has been proved by the experience gained on the Swedish State Railways where the earning capacity of their light railways has improved ever since they modified their operating methods and dieselised partially their goods services. They estimate an approximate annual saving of about one million pounds sterling if on certain light railway sections the steam traction is entirely replaced by diesel traction at an initial outlay of about 7 million pounds. And yet, this very railway administration has applied for Governmental sanction for closing wholly or in part about 85 miles of their light railway and within the next few years propose to investigate about closing down of another about 600 miles. The Victorian Railways are going to close down the only remaining section of about 34 miles of their light railways. This shows that the working of these light railways could not be maintained as they brought about heavy annual losses and there is hardly any possibility of their financial rehabilitation.

RAIL-ROAD CO-ORDINATION.

Reports received indicate that in many cases road services exist almost parallel to the existing light railways and offer keen competition. The South African Railways themselves are the largest road transport operators in the country but their road services act as feeders or supplement the carrying capacity of the railway where it is in deficit. In Sweden the railways run their own buses and lorries either directly or through private companies owned by them. Even so, large numbers of private cars offer very serious competition in carrying of passenger traffic. It has been estimated that in India and Ceylon the light railways carry about 50 % of the

total traffic offering, the rest being carried by the road services. On account of the well known advantages that the road transport has to offer, viz. its suitability for short distance traffic, its door to door service and its greater flexibility, it is unlikely that the traffic lost to the railways will ever eventually return to them in full. On the Swedish State Railways during six years between 1949-1955 passenger traffic has declined by 18 % and though the goods traffic has improved during this period the increase is much less on the railways than that accruing to the road transport system.

The railways in almost all countries, barring small lengths privately owned, have been nationalised. The road transport system with some exceptions is owned by private agencies. At present, in India the freight services are mostly privately owned and privately operated, though the passenger services have been nationalised by some states who either run them departmentally or through road transport corporations set up by them. In some of the states the Railways are also beginning to have a share in these corporations. On the Victorian Railways and in Ceylon, road services are owned entirely by private operators and the Railway Department is not, in any way, associated with their management. In South Africa, the Railways themselves own most of the road transport system.

The road transport system has the initial advantage of not having to invest any capital on construction or maintenance of roads, though they pay road taxes on the vehicles and taxes on the fuel. In South Africa the road services owned by the railways enjoy some concessions and statutory privileges the granting of which to other private bodies owning transportation is restricted.

As a result of not being governed by any definite transport obligations, road transport undertakings carry the cream of traffic, i.e. the one which is high-rated, regular and well balanced, leaving unprofitable assignments to be executed by the Railway system.

Plans for rail-road coordination are being actively pursued in almost all countries and beginnings have been made. This is essential particularly when the road transport services are going to be nationalised. It is then imperative for the Central Government who invest capital in railways and the State Governments who may own road transport to coordinate their work to avoid duplication of services and cut-throat competition. Steps are being taken by Governments — Central and Provincial — that an orderly and balanced development of all forms of land surface transport should be organised and achieved at an early date to match with the tempo of their expanding economies. Ultimately it is to the national advantage that a particular form of transport is confined to a sphere where it is most suited and economical both from the point of view of initial cost and in maintenance.

Details of road and rail tariffs have been given for both goods and passenger traffic by the Indian and Ceylon Government Railways and though, in general, those for road services appear to be higher, yet, owing to the inherent advantages that this form of transport enjoys, the road services continue to be popular.

The introduction of special services such as for collection of and delivery to the consignor of his goods have been provided at important stations on some Railways to some advantage but such services would not be justified on light railways. The use of containers on most of the reporting railways has just begun. Special sidings have been provided to important clients with large factories and manufacturing units but their utilisation is still restricted in many Eastern countries, though in Sweden about two thirds of the goods wagons are loaded on these special sidings. There does not appear to be much scope for simplification of the transport documents, though simplification of tariffs has been achieved or is being achieved on almost all the railways.

APPEND

Technical Data Concerning « Light Railways

(Ref. Question I

(Figur

N.K.

Name of the Railway administration	Total mileage of line	Gauge	Rail Section or profile	Weight per yd. in lb.	Minimum radius of curve a the prevailing degree curvature.
1. *Argentine Railways*	130	2'	N.K.	24 to 50	min. 260 ft.
	812	2' 6"	N.K.	30 to 50	Do — (where given)
	308	5' 6"	N.K.	50 to 80	min. varies between 560 ft. a 1 320 ft.
2. *Ceylon Government Railways*	110	5' 6"	Flat footed	46	Min. 1 275 ft. — 4.5° appro
3. *Indian Railways*	359	2' 0"	Do	41 to 60	Min. varies between 50 to 250
	2 264	2' 6"	Do	30 to 62	Min. varies between 48 to 1 0 ft. on different sections.
4. *South African Railways* . .	793	2' 0"	Do	30 to 52	Min. 165 ft.
5. *Swedish State Railways* . .	3 209	4' 8 1/2"	Do	55 to 82 old worn rails	Min. 820 ft. Prevailing 1 000 ft. to 3 280
	29	3' 7"	Do	50	Min. 500 ft. Prevailing 800 to 3 280 ft. for 30 to 35 % of t length.
	226	3' 6"	Do	50 — 64	Do
	1 218	3'	Do	34 — 55	Do
6. *Victorian Railways*	34	2' 6"	Do	50 to 66 iron or steel	Min. 132 ft.
Total miles	9 492				

k, Superstructure, Buildings).

a) 1-10)

ximate)

known.

Maximum & prevailing gradients	No. of sleepers per mile	Length of rack railway lines	Remarks regarding other interesting data and on maintenance of these lines.
N.K.	2 100 to 2 600	Nil	The maintenance methods are the same as for main line, though number of men employed per mile on « Light Railways » is less.
. 0.3 per cent (where given)	2 100 to 2 400	Nil	
. varies between 1.7 to 2.0 cent.	Do	Nil	
x. 1 in 60	2 112	Nil	Maintenance is manual, section divided into gang lengths. Each gang carries normal standard hand tools. No mechanical appliances used.
x. varies between 5 per cent 0.66 per cent	2 000; no longitudinal timbers used	Nil	Do Average strength of gang varies from 1 to 1.5 men per mile.
er cent uncompensated to r cent	Do	Nil	
x. 1 in 32 compensated	1 980 to 2 200 longitudinal timbers not used	Nil	Average strength of gang varies from 0.33 to 0.55 man per mile.
x. 1.7 per cent. Prevailing 0.5 l per cent for about 30 per t length	2 080 to 2 250	Nil	Track maintenance mechanised to a very small degree.
Do	2 250	Nil	
Do	2 250	Nil	
Do	2 080 to 2 250	Nil	
x. 1 in 30 compensated	2 350	Nil	

APPEND

Technical Data on « Light Railways

(Ref. Questions I

(Figur

N.K.

Name of Railway	System of traction	Maximum axle load on locos	Locomotives		Tractive effort
			Weight in service	No.	
		tons	tons		lb.
1. *Argentine Railways* . . .	Steam generally	N.K.	45 — 116	81	8 000 to 22 0
2. *Ceylon Government Railways*	Steam	7 to 9	15 — 44	N.K.	8 000 to 20 0
3. *Indian Railways*	Steam generally; a few diesel locomotives introduced experimentally on 2 sections	2 ft gauge 4.8 to 7.5 2' 6" gauge 5.5 to 9.5	14 — 58 13 — 65	63 351	6 000 to 11 0 3 000 to 18 0
4. *South African Railways* .	Steam	3.8 to 7	20 — 61	N.K.	8 000 to 18 0
5. *Swedish State Railways* . .	Steam & diesel. Diesel power for goods service and railcars for passenger service	Steam 11 to 16 Diesel 14 to 16	Steam 56 — 117 Diesel 50 — 84	N.K.	Steam 14 000 to 32 0 Diesel 32 000 to 36 0
6. *Victorian Railways* . . .	Steam	N.K.	N.K.	N.K.	N.K.

-.

r & Rolling Stock).

b) 1-3).

ximate)

known.

Years of construction of locos (giving age)	Percentage of utilisation of locomotive	Rail Cars if used			Note on maintenance and tools
		No.	HP	Type	
1920-30	42 to 85 per cent	19	100 to 140	Diesel mechanical	N.K.
1902-51	N.K.		N.K.		Maintenance is done on various schedules based on mileage or period basis. Heavy repairs in Central workshop. Light maintenance in depot. Passenger stock under repairs 6 per cent. Wagons under repairs 4 per cent.
comotives 55 years ge of others varies een 5 to 50 years	80 per cent 80 per cent	2 26	N.K. N.K.	Steam propelled I.C. engine	Maintenance is done on mileage-cum-period basis. Running maintenance depots on line. Major repairs in workshops. Tyre wear high due to sharp curve and braking, hence turning of tyres has to be done frequently.
N.K.	N.K.	Not in use at present			N.K
Steam 1900-52 Diesel 1952-56	N.K.	Passenger traffic is mostly motorised			Maintenance is done on mileage-cum-period basis. Regarding wheel tyres, no special features of maintenance are in vogue except that some diesels have flange lubricating apparatus.
N.K.	N.K.	Nil	Nil	Nil	No passenger traffic. Goods traffic is carried by goods train hauled by steam engines.

APPEND

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Operating characteris

(Figu

N.K.

Name of the Railway	Speed of trains m.p.h.	Frequency of trains per day	Density of traffic	Milea betwe stops
1. Argentine Railways *(Standard Gauge)*	21	41	N.K.	N.K
Do Do *(Narrow Gauge)*	15 — 20	Varies between 2 trains weekly to 15 trains daily	N.K.	N.K
2. Ceylon Government Railways . .	25	3 to 12	Light	5 to
3. Indian Railways *(Passengers)* . .	10 to 20	2-4 each way	6 to 17 train miles per running track mile per day	2 to
Do Do *(Goods)*	7 to 20	From occasional to 4 each way		
4. South African Railways	20 — 25	1 train each way to a biweekly train Goods 4 to 7	Light	N.K
5. Swedish State Railways	37 — 50	Minimum 2 trains each way supplemented when required	N.K.	2 to

.

(*b*) 9.

Light Railways »

ximate)

known.

. of ons) km	Composition of trains	Percentage of stations with		
		Full complement of staff	Staff dealing with booking of passengers and goods traffic only	No staff
15	Railcars as well as a train of 6 to 8 four-wheelers Mixed passenger and goods trains	N.K.	N.K.	N.K.
12	Passenger trains consist of 6 to 18 in terms of four wheelers	84	16	Nil
12	Passenger 8 to 16 vehicles in terms of four-wheelers Goods — 15-25 vehicles	56 — 83	15 to 40	Nil to 5 per cent
29	N.K.	7 to 25	2 to 3	75 — 90
12	Railcars hauling one to four coaches. Each goods train is also hauling a passenger coach.	29	21	50

PRINCIPLES OF INVESTMENT IN THE TRANSPORT INDUSTRY.

As mentioned earlier, with minor exceptions the railways are the property of the Central Government in most of the countries and the present trend is that the road transport system would soon be completely nationalised by the local or provincial Governments though at present private enterprise exists. It will, therefore, be imperative for the Governments concerned to ensure that each one of these forms of transport within the sphere for which it is best suited operates economically. In any case, the limiting factor would be the availability of the capital for the necessary expansion in each field and its allocation will have to be made by fixing priorities after taking into account the developments that are projected in any country.

CONCLUSIONS.

Most of the countries have sections of railways which would, according to the definition given in the preamble, easily qualify them for being called light railways though many railway administrations have not accepted this fact. It is true that they may not have any clear-cut demarcation between their main lines and the so called light railways. And, consequently, quite often no separate statistics of their performance have been maintained.

Laid usually to somewhat lower specifications regarding track and installations and being run over by lighter engines at comparatively slower speeds, the light railways have carried the torch of progress to the remote and the sparsely populated regions of a country, opened them to the pioneer, the entrepreneur and the colonist and provided the much-needed humanising and civilising contacts for the native populations with the rest of the world.

Another fact, which is inescapable, is that the hey-day of the light railways is past. Their importance and usefulness is generally on the decline and their financial position far from satisfactory. This has been brought about by the advent of the modern road transport system which is gradually supplanting them. Here and there efforts are being made to revitalise them and strengthen their economy and thereby obtain marginal benefits from them as long as it is possible, But all said and done, nothing can reverse the general trend that is tending to seal their destiny for ever.

[625 .14 (01]

Influence of the transverse rigidity of the track on the risk of deformation due to longitudinal compression,

by Robert LÉVI,

Director of Fixed Instalations, French National Railways

(*Le Génie Civil*, 1st July 1957.)

In an article which appeared in « *Le Génie Civil* » of 20th August, 1932 we discussed, by way of a theoretical approach, the problem of track deformation caused by heat. This theory, centred on the risk of buckling after the rising of the track, has meanwhile been extended to include the case of the bursting of concrete slabs, (e.g. for airport runways) without expansion joints (1).

Subsequently, a generalisation of the same theory has enabled us to find that the risk of track rising following upon an increase in temperature is lower (paradoxical though it may appear) with continuous track than with a track having conventional types of rail joints. It was this finding which, in France, gave rise to the policy of using welded rails of great length.

Certain authors have expressed the opinion that it would also be necessary to take into account the risk of transverse deformation without rising, and have produced formulas identical with those expressing the buckling risk after rising. For several reasons, however, this extension to transverse deformation of a theory valid for vertical deformation must lead to wholly incorrect results.

The present article is intended to rectify these errors. It may, in fact, have application to similar problems outside the sphere of railways.

The following extracts from the article referred to above, which appeared twenty-five years ago, formulate the considerations which broadly govern the research work on the risk of track rising, the method applied, and the essential conclusions.

« The applications of longitudinal compression to the rails may cause track deformations which are of sinusoidal shape and are thus similar to the buckling phenomena of beams subjected to longitudinal loads. »

« Railway engineers are, however, generally of the opinion that the phenomenon is not one of simple buckling. This is because, in practice, the track is able to move much more freely in the vertical direction than in the horizontal direction where considerable resistance from the ballast is encountered. If a buckling movement occurs, it will therefore first take the form of a rising of the track. But as this rising has the effect of practically eliminating the transverse resistance, buckling in the horizontal direction soon becomes possible. »

« This sequence of vertical and horizontal deformation is not just a matter of conjecture but has been observed whenever the deformation of the track through the heat happened to be watched by an observer. »

« In the circumstances, the maximum values to be taken into account in theory and practice are those applicable to the

(1) See the paper entitled « The risk of rising of runways and railway tracks », read on 4th March, 1947 at the « Centre d'Etudes Supérieures » of the « Institut Technique du Bâtiment et des Travaux Publics ».

rising of the track produced by the compression of the rails. »

« In order to investigate the characteristics of this phenomenon, which is similar to that of buckling, it is convenient, as in the case of buckling, to resort to the calculus of variations, if an exact solution is desired. »

« It is assumed that, between two points of the abscisssa, $+ a$ and $- a$, a deformation $y\ (x)$ is artificially provoked in a rail which is regarded as a beam of indefinite length. The value which one seeks to determine is the variation ΔV of the internal potential. »

And, later :

« The position of an object which possesses weight, which is subjected to longitudinal compression, which is placed on a horizontal plane and able to rise, is therefore different from that of an object that possesses no weight. Its buckling can be provoked but this must be done by enforcing a deformation which must be the smaller, the greater the compression. »

« Buckling under normal conditions is analogous to the reversal of the movement of a pendulum when its centre of gravity has been raised above its axis of rotation. The case of buckling here encountered is comparable to the case that would be produced if one were to lift a pendulum slowly, by supporting it on one side, until its centre of gravity is very nearly above the axis of rotation. It is, as it were, a case of unstable equilibrium. »

Whether one uses the theory of variations as mentioned above, or tries to determine an equilibrium position at the limit of stability, the results are obviously the same in the case of track rising.

If P is the longitudinal compression in each rail, ω the weight per metre of the rail and of that part of the track carried along by the rail, and I the moment of inertia in the vertical direction, the differential equation which must be satisfied can be written :

$$\mathrm{E}\mathrm{I}y^{\mathrm{IV}} + \mathrm{P}y'' + \omega = 0 \qquad [1]$$

With the limit conditions derived from the support of the rail at the abscisses $\pm\, a$, one obtains the solution :

$$y = \frac{\omega}{\mathrm{P}}\left(\frac{\cos \omega a - \cos \omega x}{\omega^2 \cos \omega a} + \frac{a^2 - x^2}{2}\right) \qquad [2]$$

where :

$$\omega = \sqrt{\frac{\mathrm{P}}{\mathrm{EI}}} \qquad \omega a = \tan \omega a = \varphi\,. \qquad [3]$$

In the case of a simple wave where $\varphi = 4.5$, the limit value of energy to be applied in order to produce unstable equilibrium has its smallest value at

$$\Delta V = \frac{\omega^2 \varphi^2}{3\mathrm{P}}\left(\frac{\mathrm{EI}}{\mathrm{P}}\right)^{\frac{3}{2}} \qquad [4]$$

The minimum deformation is thus characterized by the following values :

Length :

$$2a = \frac{2\varphi}{\omega} = 9\sqrt{\frac{\mathrm{EI}}{\mathrm{P}}} \qquad [5]$$

Amplitude :

$$y(0) = \frac{\omega}{\mathrm{P}\omega^2}\left(1 + \sqrt{1 + \varphi^2} + \frac{\varphi^2}{2}\right)$$

$$= 15.7\,\frac{\mathrm{EI}\omega}{\mathrm{P}^2}\,. \qquad [6]$$

What changes must be made in this method if a horizontal deformation is envisaged?

One may assume that the friction on the ballast has a constant value per unit of length which we may call $2\,\tau$ and which acts in the direction opposite to that of the movement envisaged. It would thus seem that equation [1] should also be applicable on the condition that ω is replaced by τ and that I is taken to mean the moment of inertia of the rail about its vertical axis.

Here lies a first error. If, in fact, equation [1] would be applied without further modification, one would obtain a solution of the type [2] which would, however, yield a value of y''' and thus of the transverse force, which would not be zero at the ends (fig. 1), and that is inconceivable.

In the case of the vertical buckling of an object placed on incompressible supports, the transverse force at the ends of the deformed part may disappear abruptly at a support point acting as abutment. But this is not possible in the case of a piece which is kept in place merely by an evenly spread resistance to friction.

In reality, the equilibrium of the transverse forces must apply to the deformed length itself which means that the sign of τ must be alternately positive and negative.

The part most affected by the deformation will have the form of a simple wave. The central half will be resisted by the support whilst the first and last quarter will be supported in the opposite direction (fig. 2).

If the length be 4 l, the differential equations applicable to a track without frame rigidity are :

for

$$0 < x < l \quad EIy^{IV} + Py'' + \tau = 0. \qquad [7]$$

for

$$l < x < 2l \quad EIy^{IV} + Py'' - \tau = 0.$$

with

$$\Omega = \sqrt{\frac{P}{EI}}. \qquad [8]$$

the solution is given

For $0 < x < l$,

by : $\frac{P}{\tau} y'' = -1 - 3 \cos \Omega x$

For $l < x < 2l$,

by : $\frac{P}{\tau} y'' = 1 - \cos \Omega (2l - x)$ [9]

and $\Omega l = \pi$ [10]

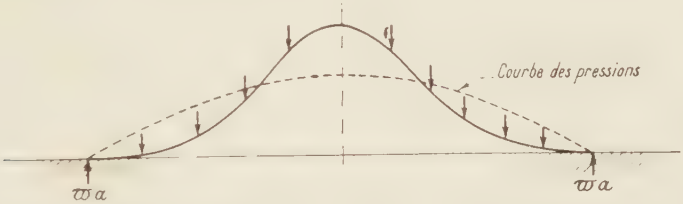


Fig. 1. — Critical equilibrium in the case of vertical rising of the track.
Courbe des pressions = pressure curve

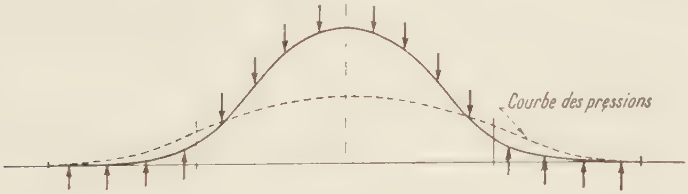


Fig. 2. — Critical equilibrium in the case of resisted (horizontal) deformation of the track.
Courbe des pressions = pressure curve

It follows that, in the equations for length and amplitude, the numerical coefficients differ from those of [5] and [6].

A second error which is superimposed on the one just discussed consists in the assumption that, in respect of horizontal bending, the track behaves like a beam in accordance with the hypothesis of plane sections, implying the existence of the complete moment of inertia :

$$J = 2\left(I + \frac{Sh^2}{4}\right) \qquad [11]$$

which would yield :

$$\omega = \sqrt{\frac{P}{EJ}} . \qquad [12]$$

This hypothesis is not admissible in the case of the track, firstly because of the elasticity of the sleepers and their housings at the rails and secondly because of the swivelling sliding movements in these housings.

Let us, for the time being, neglect this second factor. Let α be the rotary movement, in relation to the rails, of the straight line connecting two points located on the same perpendicular, in the absence of a moment at the support. To an angle α corresponds a moment which we shall assume to be proportional to it, and which we shall call $K\alpha e$, where e is the sleeper spacing. The coefficient of the evenly spread resistance, K, has the dimension of a force.

Let us assume, by way of simplification, that there is one sleeper per unit of length. The internal equilibrium of the system requires that the two halves exert an equal pressure of $2K\alpha/h$ against each other (fig. 3).

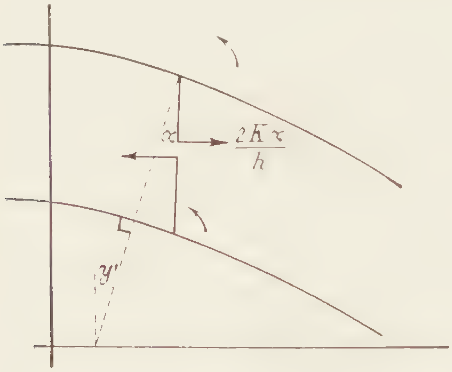


Fig. 3.

If $P + \delta P$ and $P - \delta P$ are the compression forces acting in the two strings of rails, one obtains :

$$P' = + \frac{2K\alpha}{h} \qquad [13]$$

and

$$\frac{h}{2}(y'' + \alpha') = \frac{\delta P}{ES} . \qquad [14]$$

Finally, the moment 2M, with the conventional sign, becomes :

$$2M = h\delta P + 2EIy'' . \qquad [15]$$

By eliminating δP and α from these three equations, one obtains :

$$EIy^{IV} - \frac{KJ}{J - I} y'' = M'' - \frac{KM}{E(J - I)} . \qquad [16]$$

In all practical cases, J is considerably greater than I so that it is permissible to apply certain simplifications. For the time being, it is sufficient to introduce a very slight modification of the definition of K in order to transform [16] into :

$$EIy^{IV} - Ky'' = M'' - \frac{KM}{EJ} . \qquad [17]$$

If y is known, α can be determined from :

$$K\alpha = M' - EIy''' . \qquad [18]$$

A first application of these equations enables us to relate the value of K to the results of bending tests. If F be the transverse force exerted on the track at the centre of a simple span of the length l, and if f be the deflection, the calculation yields :

$$f = \frac{F}{96EJ}\left[1 + \frac{3J}{I}\,\frac{\mathrm{th}\frac{\theta l}{2}}{\left(\frac{\theta l}{2}\right)^3}\right] \qquad [19]$$

where

$$\theta^2 = \frac{K}{EI} .$$

It is found that the values of K thus determined are amazingly close to each other. Whether or not the wooden sleepers are fitted with tie-plates, whether they are fastened by strong clips or screws, the numerical value of K differs little from 14 tons. The greatest deviation encountered is less than 10 %, in the case of sleepers laid on grooved rubber pads.

This value of K is greatly inferior to that of the force liable to be introduced into each rail due to thermal stresses which may reach a value of about 50 tons.

Let us now deal with the buckling problem, keeping in mind that, for a reason already explained, the density τ of the transverse force in the central half of the wave must be given a sign opposite to that in the first and fourth quarter. The moments are as follows :

for

$$l < x < 2l$$

to

$$2M = -2Py - \tau(2l - x)^2 + C^{te}$$

for

$$0 < x < l$$

to

$$2M = -2Py - \tau(2l^2 - x^2) + C^{te}$$

Hence the differential equations :

$$\left.\begin{aligned} &EIy^{IV} + (P - K)y'' - \frac{KP}{EJ}y \\ &= \tau - \frac{K\tau}{EJ}\left[\left(\frac{2l - x}{2}\right)^2 + a\right] \\ &\text{and} \\ &EIy^{IV} + (P - K)y'' - \frac{KP}{EJ}y \\ &= -\tau - \frac{K\tau}{EJ}\left(l^2 - \frac{x^2}{2} + a\right) \end{aligned}\right\} \quad [20]$$

where a is a constant.

Because of the symmetry conditions in relation to the centre, and the continuity conditions of y' and y''' at the end, the solution must be of the following form :

$$\left.\begin{aligned} &\frac{P}{\tau}y = \frac{(2l - x)^2}{2} - \frac{EJ}{P} + a \\ &+ A\,ch\theta\,(2l - x) + B\cos\omega(2l - x) \\ &\frac{P}{\tau}y = l^2 - \frac{x^2}{2} + \frac{EJ}{P} + a \\ &+ A'\,ch\theta x + B'\cos\omega x \end{aligned}\right\} \quad [21]$$

where $\pm\,\theta$ and $\pm\,i\,\omega$ are the roots of the characteristic equation [20] which have the following approximate values :

$$\left.\begin{aligned} \theta^2 &= \frac{KP}{EJ\,(P - K)} + \dots \\ \omega^2 &= \frac{P - K}{EI} + \dots \end{aligned}\right\} \quad [22]$$

With the aid of the continuity conditions of y' and y''' for $x = l$, one obtains immediately.

$$\omega l = \pi \text{ and } A' = -A. \qquad [23]$$

It remains to determine A, B, B′ and a from the continuity conditions of y and y''' at the abscissæ l and $2\,l$, and to determine, with their aid, the deflection y (0).

One obtains :

$$2A\,ch\,\theta l - 2\frac{EJ}{P} = B - B'$$

$$2A\theta^2\,ch\,\theta l + 2 = \omega^2\,(B' - B)$$

$$a - \frac{EJ}{P} + A + B = 0$$

$$A\theta^2 - B\omega^2 + 1 = 0$$

$$\frac{P}{\tau}y\,(0) = l^2 + \frac{EJ}{P} + a - A + B'$$

Hence the exact equation :

$$\frac{P}{\tau}\,y(0) = \frac{\pi^2}{\omega^2} + 4\frac{EJ}{P} - 2\left(1 + \frac{1}{ch\frac{\theta\pi}{\omega}}\right)\frac{\omega^2\frac{EJ}{P} - 1}{\theta^2 + \omega^2}. \qquad [24]$$

If this equation is developed as a series, it is found that the result can be obtained to within the nearest 1/1 000th by eliminating from equations [20] those terms where J figures in the denominator.

Amplitude :

$$y\,(0) = \frac{EI\tau}{(P - K)^2}\,(\pi^2 + 4) = 13.8\,\frac{EI\tau}{(P - K)^2}. \qquad [25]$$

According to [22] and [23], the approximate value of the length of the deflection is as follows :

Length :

$$4l = 4\pi\sqrt{\frac{EI}{P - K}}\,. \qquad [26]$$

The fact that J figures neither in the approximative equation of the length nor in that of the amplitude shows that it is illusory to count on the complete inertia of the track in combating the risk of transverse deformation if such a risk should be present. Moreover, as the value of the rigidity coefficient K is always of the same order of magnitude because of the elasticity of the sleeper between the rails, it would be fallacious to judge the fittings of the track by the rigidity of the housing itself.

In fact, a comparison of [11] and [12] with [25] and [26] shows that, compared with a complete freedom of rotation at the system points formed by rails and sleepers, the locking effect of the fastenings increases the length and amplitude of the critical deformation at the following ratios, respectively :

$$\left(\frac{P}{P - K}\right)^{\frac{1}{2}}$$

i.e. between 1.13 and 1.19.

and

$$\left(\frac{P}{P - K}\right)^{2}$$

i.e. between 1.84 and 1.99

if $P = 48$ tons and if K ranges between 12.6 and 14 tons.

Finally, it may be noted that the characteristics of the critical deformation cannot be deduced from the consideration of a fictitious moment of inertia, to be substituted for I in equation [11] and [12].

We shall now examine the case where, owing to the existence of lateral play and weak friction resistance under the foot of the rail, the latter is able to slue in relation to the sleeper, with a not very high value of the moment at the support. It has been found experimentally that the proportionality of this moment to α is limited to a value $K\alpha = C$ where C is of the order of 0.25 tons only if the rail rests on a metal plate, whilst the coefficient is much higher if the foot of the rail rests either directly on the sleeper or on a rubber pad.

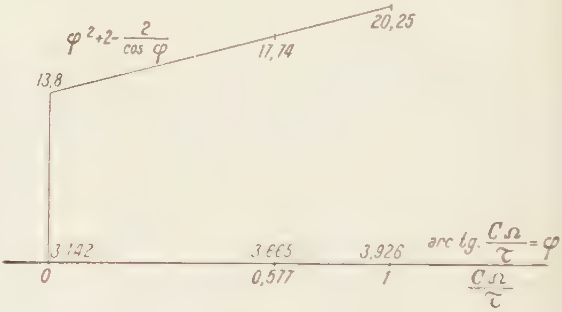


Fig. 4.

The foregoing calculation cannot be applied to the case of contact between metal and metal.

We shall assume, and this assumption will be justified later, that the critical deformation will only admit of short lengths without rotary sliding movements. Over those short lengths, we may assume the complete inertia as characterized by the parameter ω [14]. On the other sections of the deformation, however, a quantity which varies in linear proportion with a slope ± 2 C is interposed between the moment M of the forces applied to the beam and the bending moment of the strings, $2\,EIy''$, where the sign $\pm$ is obviously chosen deliberately.

By using the parameter Ω defined by equation [8], it is possible to write, for the zones without sliding :

$$\frac{y^{IV}}{\omega^2} + y'' = \pm \frac{\tau}{P} \qquad [27]$$

and for the zones with sliding :

$$\frac{y'''}{\Omega^2} + y' + \int \pm \frac{\tau}{P}\,dx = \frac{C}{P}\,. \qquad [28]$$

The calculation thus begun yields an angle φ which, for a single-wave deforma-

tion, is slightly greater than π and is approximately given by

$$\tan \varphi = \frac{C\Omega}{\tau} = \frac{C}{\tau} \sqrt{\frac{P}{EI}}. \qquad [29]$$

The length of the critical deformation is

$$4l = \frac{4\varphi}{\Omega} = 4\varphi \sqrt{\frac{EI}{P}}. \qquad [30]$$

The amplitude has the following approximate value (fig. 4) :

$$y(0) = \frac{EI\tau}{P^2} \left(\varphi^2 + 2 - \frac{2}{\cos \varphi} \right). \quad [31]$$

The term in brackets deviates only very slowly from the value 13.8 which it possesses when the rigidity of the fastenings is zero. The risk of transverse deformation due to longitudinal compression is therefore hardly counteracted by the use of fastenings of great locking power unless the foot of the rail rests directly on the sleeper or is fastened to it by means of a rubber pad.

The results can be summarized as follows :

Given :

$2\,\tau = 400$ kgs. pr. metre $\quad P = 0.0004$ ES

	Length of critical deformation (metres)	*Amplitude of critical déformation (metres)*
Hypothesis of the moment of inertia reduced to that of the rails	15.12	0.084
Correct calculation for fastenings of high locking power, but with metal metal friction : C = 250	19	0.125
Correct calculation for ordinary fastenings, with the rail resting direct on wooden sleepers K = 12.6 tons	17	0.155
Hypothesis of the complete moment of inertia.	472	82 (theoretical)

The mere comparison of these numerical results shows the dangers inherent in the study of buckling phenomena. In the absence of a precise analysis, one is liable gravely to underrate the risks and to attach importance to factors which only play a secondary part.

The difficulties encountered in this respect are largely due to the fact that, in the theory of the strength of materials, the normal cases are covered by linear equations, and that the routine procedure based on these is of no avail as soon as the sphere of linearity is left behind.

Experience with small deformations shows that the deflection is proportional to the stresses. But, in order to initiate the buckling of a ladder-shaped girder the movement of which is resisted in the transverse direction, an initial deformation is required which transcends the sphere of linearity. If the moments at the system points are confined to an insignificant value, a superimposed deformation is merely resisted by the moments of inertia of the strings of rails.

Experience with small deformations also shows that, as soon as the amplitude is increased artificially, the reaction is always opposed to the elongation. But if the critical deformation is approached, the thrust tends to reverse the direction of the forces in those parts where the curvature is contrary to the elongation. The buckling begins by making the deformation wider and, at the same time, shorter.

As regards the risk involved in strong longitudinal compression of the track, we reiterate the statement that the effect of this risk is, in practice, confined to the stability of the track in the vertical direction. Regardless of the way in which the rail is fastened to the sleeper, the initial deformation required to initiate the horizontal buckling is too great to be ignored. But it would be erroneous to think that such measures as the use of rigid fastenings with tie-plates constitute an effective increment of the rigidity of the track in respect of these deformations.

In actual fact, the resistance to the transverse force is almost exclusively obtained from the rails. To increase this resistance, it is preferable to ensure a good adhesion of the foot of the rail to the sleepers rather than to try and improve the locking effect of the fastenings.

[656 .254 (73)]

10 years of railroad radio.

Where we stand — what's ahead.

(*Railway Age*, September, 2, 1957).

« I don't see how we operated before radio. »

The healthy 10-year old is growing fast. About 180 railroads, including short lines and switching and terminal companies, have installed two-way radio.

Railway Age's annual surveys show that in 10 years since 1946, radio was installed on 7 450 locomotives, in 2 754 cabooses and at 1 441 wayside offices. Railroads have also purchased 2 889 walkie-talkies.

Equipment installations have averaged 2 500 radio units per year, over the past five years, and should continue for several years more. The point of saturation has not been reached. For example, only 28 % of the locomotives, 14 % of the cabooses and 15 % of the wayside offices are equipped with radio.

Another impetus for further growth is that new uses are being discovered every day for this fast communications medium. The outlook is that by 1965 radio will be as commonplace on the railroads as the telephone is today.

YARD RADIO

The reasons for this phenomenal growth of railroad radio are quite obvious when you visit the railroads and see what they are accomplishing with it. One of the first uses of radio and one of the most widespread today is for yard service, in which yard switching locomotives are equipped with two-way radio. A radio base station, usually at the yard office, provides communications between the yardmaster and the switch engines.

Much time is saved with yard radio. The yardmaster no longer has to spend time hunting for his engines. He calls them on the radio to ascertain their locations, and gives them instructions. Some roads having several switchers at a yard are able to cut off one or more engines because of the increased efficiency of the remaining locomotives equipped with radio.

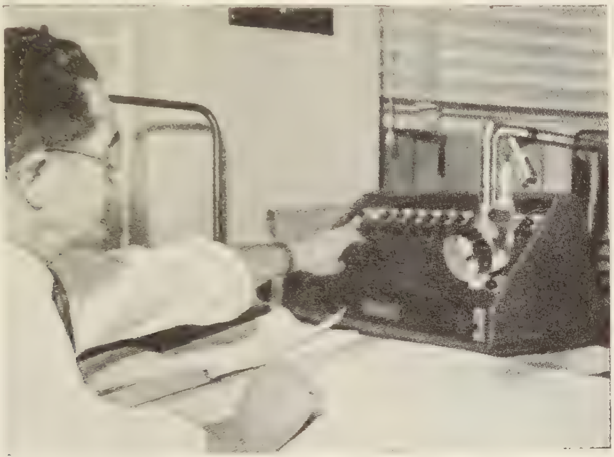
Improved service to shippers has resulted from the use of radio in yards and terminals. Shippers are able to get cars switched promptly. Prior to radio, they would telephone the yardmaster and he would spend considerable time trying to locate an engine to perform the switch. In many instances, he had to send an engine out from the yard to make the switch. Now he can quickly radio his engines and find out which locomotive is nearest to the shipper's plant, and direct it to do the work.

One road has found that by radio usage it has been able to pick up « hot shot » cars from industries in the late afternoon in time for these cars to make outbound trains. This road also has had increased business from shippers since the radio was installed. Summing up — yard and terminal radio saves time and money, improves operations and service to shippers.

RADIO ON TRAINS

End-to-end radio usage on locomotives and cabooses of freight trains came next. On one 1 300-mile run on single track, an installation of end-to-end radio made

an overall saving of 5 1/2 hr on each freight train. Each train saved 5 to 10 min in entering and leaving sidings, because the conductor could radio his engineer where the caboose was, and when the brakeman was on board after closing the switch. Many railroads have had less break-in-twos since installing train radio, because the conductor, in an emergency, radios the engineer to stop the train rather than « pulling the air » from the caboose.



Q : « What are you doing 516? »

A : « We're setting out four cars of sand. »

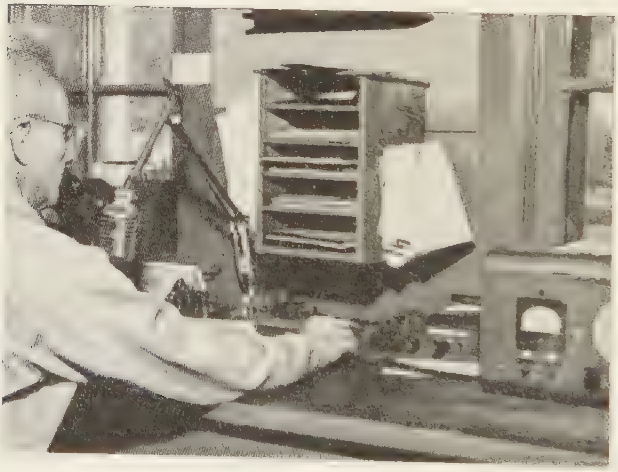
Wayside offices equipped.

One western railroad reports that the time saved in getting trains over the road

between terminals on a division, by equipping them with radio, eliminates one 4-unit diesel locomotive. In other words, without radio, it would require one more freight locomotive to move the same number of trains.

The next step from end-to-end was the logical one of equipping wayside offices with radio for communication between dispatchers or operators and freight trains. The advantages are many. With wayside stations about 30 miles apart, a train is always within radio range of a base station. This spacing also makes it possible for base stations to communicate with each other when line wires are down due

Q : « What work have you got for us? »

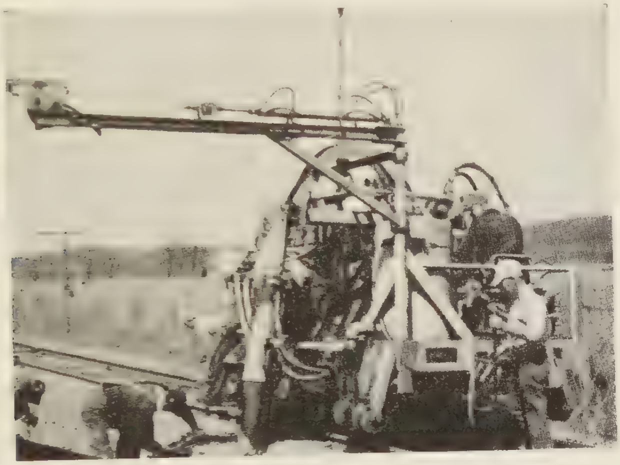


A : « Two box cars on the house track. »

to storms, thereby providing emergency communications.

Train-to-wayside radio enables a dispatcher, for example, to be promptly informed when a train is delayed. Thus he can rearrange meets to reduce further delays to other trains.

Train-to-wayside radio is used extensively by crews on local freight trains, which set out and pick up cars at various towns. One railroad has found that the local freight has been able to eliminate all overtime since it has been equipped with radio. When the local is 5 to 10 miles from a town, the conductor radios the agent concerning work to be done.

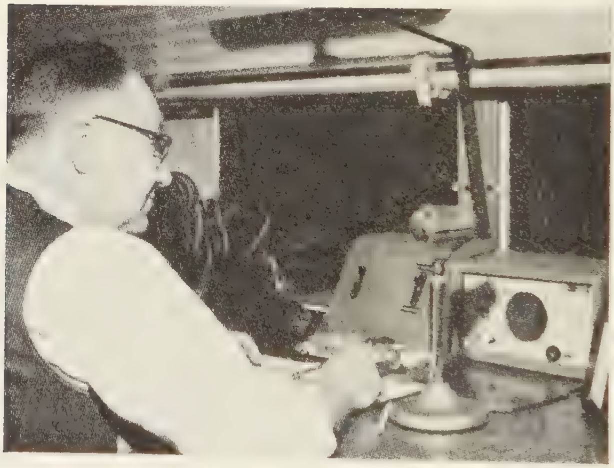


Q : « Any sign of 18 yet? »

A : « He just called me 10 miles out. »

In many instances, cars are to be picked up or set out on the outskirts of the town, before the local reaches the depot. Without radio, the local would pull down by the depot, the conductor would talk to the agent to find out the work to be done. Often they would backtrack out to the edge of town to switch plants or pick up cars which they had passed on their way to the depot.

Q : « We're done at Smith street, What next ? »



A : « Go over to Acme Lumber for a switch. »

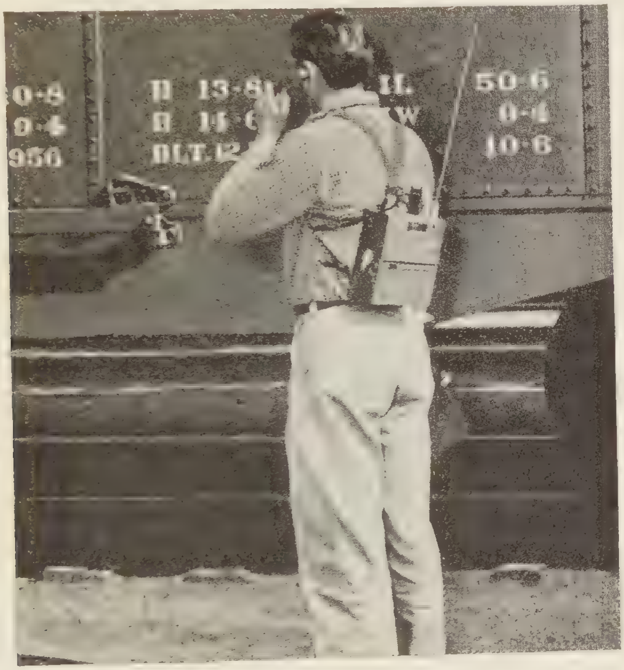
To make effective use of wayside radio stations when the offices are closed, or to use unattended radio stations, remote controls were developed which enabled the dispatcher to operate the radio stations. When the dispatcher desires to call a

train, he operate a selector key, his « voice » goes over telephone wires to the local wayside radio station and from there via radio to the train. Thus he can talk directly to trains, and their crews in turn can call through the wayside stations and talk directly to him.

One western railroad which had wayside radio stations in service for several years on local control, recently put in dispatcher control because they had a 250-mile gap at night where there was only one station open 24 hr. With dispatcher control of the wayside radio stations, he had, in effect, open offices about every 30 miles across the entire gap.

RADIO FOR AUTOS

Another step was to equip automobiles, trucks and track motor cars for trainmasters, yardmasters, superintendents and road foremen of engines. Railroads have found that in terminal areas radio for these men has been a tremendous time saver, because they can be continually on the move. Radio keeps them informed of operations and enables them to be reached and to communicate with trains and their offices.



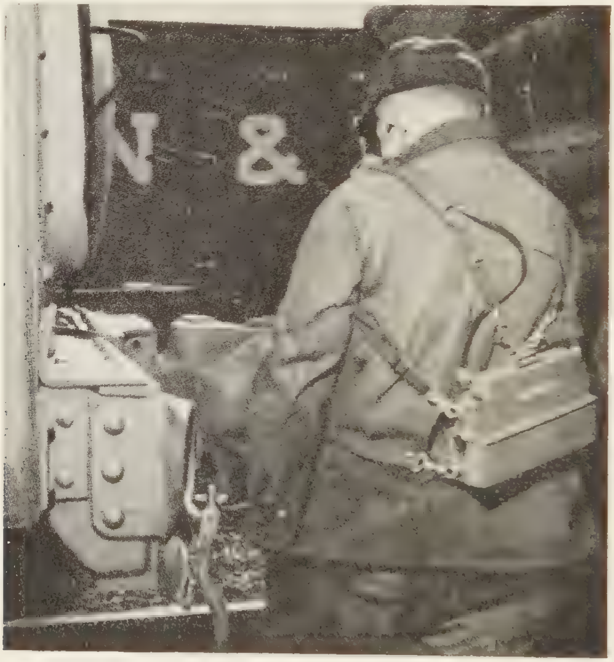
Yard clerk . « 76-541, a Santa Fe box. »

One trainmaster says he has cut his driving considerably since his automobile has been equipped with two-way radio. Often he can give instructions from his car without driving to the scene of operations. Many road foremen of engines have found that when locomotives develop trouble, they can radio repair instructions to the crew. This often eliminates the necessity of sending a truck and mechanic to the locomotive.

Trucks are also being radio equipped

for use by communications, signal, maintenance-of-way and car departments. Some railroads have used a station wagon or panel truck for a mobile radio shop, complete with tools, test equipment and radio to serve as an emergency base station.

equipped. The foreman carries a walkie-talkie. This road issues specific train orders for approaching trains concerning the working limits of the gangs, which include the name of the gang foreman. The train crews calls the foreman for instructions about moving through the work limits.



Car inspector : « I think I got a bad order. »

M/W department radio.

The maintenance-of-way department is using radio to increase the production time of gangs and expensive on-track equipment. An adjunct of this radio usage is that train delays are also being reduced and in many cases eliminated where trains encounter these gangs along the line.

One midwestern railroad has equipped rail, track surfacing and tie renewal gangs with radio. Each gang has several trucks and on-track machines which are radio

Because the train crew radios ahead, the foreman can usually have the track clear when the train arrives. Production time is increased because the gang gets in the clear when the train is heard from. Previously if a train was late, the gang spent time « in the clear », which they could have spent working. Some roads give radio to the flagmen with these gangs, so they can communicate with approaching trains, instructing them concerning track conditions.

In addition to keeping trains moving, the m/w department of one railroad finds

that the foreman of the surfacing gang can keep better control over his operations with radio. Because the on-track machines may be spread over a half mile of track or more, the foreman keeps in touch with all machines by using the radio. « It certainly has saved me a lot of walking, and I'm not as tired at the end of the day as I used to be », he stated.

One railroad has radio on a wrecker crane, and the foreman carries a walkie-talkie or a portable radio transmitter to call the crane. Therefore he can stand on the ground, away from the crane, and direct operations by voice communications. This road says this is most effective, because as the foreman puts it, « I can give the operator detailed instructions about moving cars or engines. It's safer that way, because the operator has only to watch his hook, whereas before he had to watch it as well as look for hand signals. Radio gives us precise control of the wrecker ».

WALKIE-TALKIES.

Many roads are equipping cabooses and locomotives with walkie-talkies, in addition to the standard high-power 30 watt sets. When trainmen go out to inspect the train or direct switching moves, they take radio right along with them.

Among major uses of walkie-talkies are (1) car checking and (2) car inspection work. In car cheking, the clerks carry radio packsets as they walk down a line of freight cars, or they are located at a point where trains pass them. They read off initials, number and kind of car into their packset « mikes ». This clerk's voice is picked up by a radio base station at the yard office where it is fed into a recorder, or directly written down by another clerk. The recordings are transcribed later. This method of radio checking saves time.

Car inspection work using radio has produced much saving of time. Car inspection systems are generally of two types : (1) all radio and (2) radio with a paging speaker system. In the all-radio system, the car inspectors are equipped with walkie-talkies which transmit on one frequency and receive on another. The inspectors talk to a receiving station, which picks up the voice and puts it on a wire circuit to the lead car inspector or foreman's office. This is also transmitted by wire to a transmitter about 1/2 or 1 mile away and rebroadcast at a different frequency. When the foreman talks, his voice goes via wire circuit to the radio transmitter and is broadcast.

In the radio-loudspeaker system, the inspectors have small portable radio transmitters. They talk into them, their voices being picked up by a radio receiving station and fed not only to the speaker in the foreman's office, but also to a paging speaker system in the yard. Thus the inspectors talk on radio, and listen to the paging speakers. The car foreman talks on the paging speaker system. When the foreman is out in the yard, he carries a walkie-talkie or portable transmitter for communications. Thus he can be called regardless of his location.

One of the most important uses of radio by the inspectors is to coordinate their actions when setting out or removing blue flags at the ends of cars. Radio has also increased their efficiency because the foreman can promptly give them their next assignment, whereas formerly he had to wait until they called him on a telephone.

The radio has also been a great « *step-saver* » in this work. Often the inspectors use radio to consult their foreman about bad order cars and regarding minor repairs to be made in the yard. One road has a car department truck equipped with radio, and in one instance, the truck was called by radio and went to a freight train on the main line. The car men repaired a journal so that the train was able to proceed without having to set the car out. Again time was saved.

Other uses of walkie-talkies are for directing switching operations during fogs; for setting stakes and reading levels by surveying parties; aligning searchlight signals; and checking switch positions and signal aspects when cutting in a new interlocking.

Railroads are also equipping fork lift trucks, tractors and other materials-handling equipment at freighthouses and shops for coordinating their operations. One road has equipped an overhead traveling crane with radio so that the foreman on the shop floor can give detailed instructions to the crane operator. As one man said, « when you can talk to a fellow, you can do your job so much better, and so can he ».

When agents or operators at wayside radio stations see a hot box, dragging equipment or a shifted load on a passing freight train, they inform the engineman by radio. One railroad man said, « the fact that radio has saved us several potential severe accidents more than justifies its cost. One derailment will pay for a great deal of radio equipment ».

WHY THE FUTURE IS BRIGHT.

« When you can communicate, you can keep trains moving ». That just about sums up the underlying reason why radio has been so successful on railroads. Keeping trains moving also implies keeping cars moving in yards and terminals. That's why yard radio is so vital. Many railroad men say today that one of their biggest challenges is reducing time spent by freight cars in yards and terminals. Radio can reduce that time considerably.

The future of radio, as far as technical developments are concerned, is very bright. The single package radio unit with the transmitter, receiver and power supply in one case, which is interchangeable, is now standard, accepted by the AAR. Thus radio units on locomotives, cabooses and in wayside stations can be interchanged, providing they operate on the same voltages.

One of the most important developments is the use of transistors, which replace vacuum tubes and require less power. The transistor power supply is here. This unit eliminates the need for vibrators or engine-generator sets to supply power for locomotive radio. These new power supplies weigh less, because they do not have the « big weight unit » of the old ones, namely the transformer. One single-package radio unit just developed weighs less than 25 lb. Transistor walkie-talkies are down to 9 lb. These lighter weight, smaller units have less power consumption and longer life, and they are easier to handle.

« Split-channel » radio operation, in which railroad radio equipment will have to operate on narrower channels than at present, is to be completed by 1962. By that time some railroad radio will be operating on new frequency assignments. But this is only a minor technicality because radio equipment manufactured for the last couple of years is capable of split-channel operation. And most other radio units can be converted for as little as $ 10 per unit. The Federal Communications Commission is expected to hold hearings on assignments this fall.

With its tremendous savings in time and money with improvement in operations, it is hard to see why any railroad will try to operate without radio.

[**625** .144 .1 (73) & **625** .173 (73)]

Handling continuously welded rail.

Strings of continuously welded rail are pushed off the rail train at the relaying site instead of the more usual pulling off.

(*The Railway Gazette*, October 25, 1957.)

The increasing use of continuously welded rails, especially in the U.S.A., has prompted new developments in handling the rails between the depots at which the welding takes place and the site at which they are to be laid in the track. Hitherto the method of unloading generally practised has been to anchor one end of each pair of rails in succession (as they lie on the flat wagons in the rail train) to a fixed point in the track below, by means of wire ropes hooked through the bolt holes, and then to draw the rail train away from them. The movement is facilitated by equipping the flat wagons with skids and rolllers on which the rails rest. The far ends of the rails, as they drop down on to the ballast, must be protected from buckling or damage by fitting the rear end of the rail train with some kind of inclined apron, so that the rail-ends slide downwards rather than falling with undue violence.

Threaders on second idler car carried by rail supported by brackets built into rear bogie of wagon.

The Denver & Rio Grande Western

Railroad recently perfected a new unloading method, which is to push the rails off the rail train rather than to pull them.

Locomotive at unloading point.

The purpose of this is to have the locomotive of the rail train adjacent to the actual unloading point, instead of ¼-mile or more away, with resultant time-lag in the transmission of signals between the locomotive crew and the unloading gang. Actually on the D.R.G.W.RR. the strings of rails are welded together to make an exact fit to the length of track which is being relaid, and so may range from 33 to 41 39-ft. rails welded together, or 1 287 to 1 599 ft. in all. The rail concerned is of the A.R.E.A. standard 110 lb. per yd. f.b. section.

Specially adapted flat wagons.

Next to the locomotive, which is a diesel-electric unit of the B-B shunting or general purpose type, two specially adapted flat wagons are interposed before the first of the rail train flat wagons proper. The interposed wagons are fitted on each side with threaders, attached to brackets, one pair to each wagon; the pair on the wagon furthest from the locomotive are mounted above the floor level, and those on the wagon next the locomotive are welded to the frame of the leading wagon bogie. As the continuous rails pass through the threaders, the latter direct them downwards so that they reach the toe of the ballast just abreast of the locomotive, one on either side.

The first operation is to pass short lengths of 110-lb. rail transversely through each pair of brackets, and then to fit the threaders under them. Next, wire ropes are attached by hooks to the bolt-holes at the leading end of the first pair of continuous rails to be unloaded, and the other ends of the ropes are hooked in to the knuckle pin of the locomotive coupling, the locomotive having been uncoupled from the train. The locomotive then moves forward, drawing the leading ends of the rails through both pairs of threaders and down to ballast level. Here they are connected by fishplates with the ends of the two previous continuous rails unloaded, which have been temporarily anchored to another short length of rail laid transversely across the track between two sleepers.

The locomotive is now recoupled to the train and begins slowly to push, proceeding until the first pair of rails is nearly off the leading rail wagon. At this stage yokes, with short lengths of cable attached, are pinned through the bolt-holes of the next pair of continuous rails to be unloaded, and similar yokes are attached to the trailing ends of the pair which are nearly unloaded.

Automatic alignment.

As the trailing ends of the first pair of rails pass by the leading ends of the second pair, the cables are slipped over the pins, and the first pair now begins to pull the second pair, automatically aligning the rail-ends, with a slight gap between them.

At this stage the train is stopped, the yokes are removed, and fishplates are substituted, temporarily secured by flat pins held in place with cotter keys, as fish-bolts and nuts would not pass through the threaders. The train then moves on and the operation continues until the last string has been dealt with. After the first rails have been threaded, a total of 16 strings — eight pairs — can be unloaded in about 1 ½ hr. by four or five section men, additional to the train crew and supervisor. Experience has shown this method to be practical, efficient and economical of both time and labour.

[656 .212 .8 (73)]

Car weights by the trainload.

Revolutionary method permits weighing in motion without uncoupling. Claimed benefits include savings in time and expense without capital investment by the railroad.

(*Railway Age*, November 11, 1957).

Recently a large group of railroad men, shippers and state government officials stood alongside what had been a more or less « top secret » piece of track. This track, off to one side of the Monon's yard at Hammond, Ind., is the test and develop-

Test Site consists of track at one side of the Monon's flat yard at Hammond, Ind. Site is leased from railroad by the manufacturer.

ment site for a relative newcomer to the railroad field — the International Railroad's Weighing Corporation of Indianapolis — developers of a car weighing method called « Railweight ».

What they saw is pictured on these pages; a stretch of track punctuated by a slight « hump » in the rails, leading to an unusually short track scale. Within the modest frame scale house immediately adjacent to the scale, veteran railroaders looked in vain for some radically new equipment. They saw none. The scale itself, a mere 12 ½ ft. long, is a standard Fairbanks Morse lever-type knife-edge track scale; the recorder is a simple Streeter-Amet tape printer.

Many were inclined to disbelief before the demonstration began. How, one railroad man reasoned, can it be possible to weigh cars accurately — while coupled and in motion — with anything so simple as this? The secret is in the « hump » section of the approach track.

As the demonstration proceeded, amazement took the place of skepticism in many minds. Running at a speed of about 2 m.p.h., a train of loaded cars was pulled over the scale. As each truck passed over the scale, its weight was recorded. Adding the readings obtained from the two trucks of each car provided total car weight.

The question of accuracy was, of course, immediately raised. What about weight transfer from car to car through the couplers? The accuracy of the weights obtained was found to be well within the required 0.2 % tolerance. And, as to transfer of weight from car to car through the couplers: there wasn't any. Slowly came the realization that here at last was a weighing method which, to all appearances, could do what had never been done before.

No railroad investment.

After the technical features were explained, Samuel H. Levinson, president of the firm, went on to explain his company's plans. The Railweight weighing

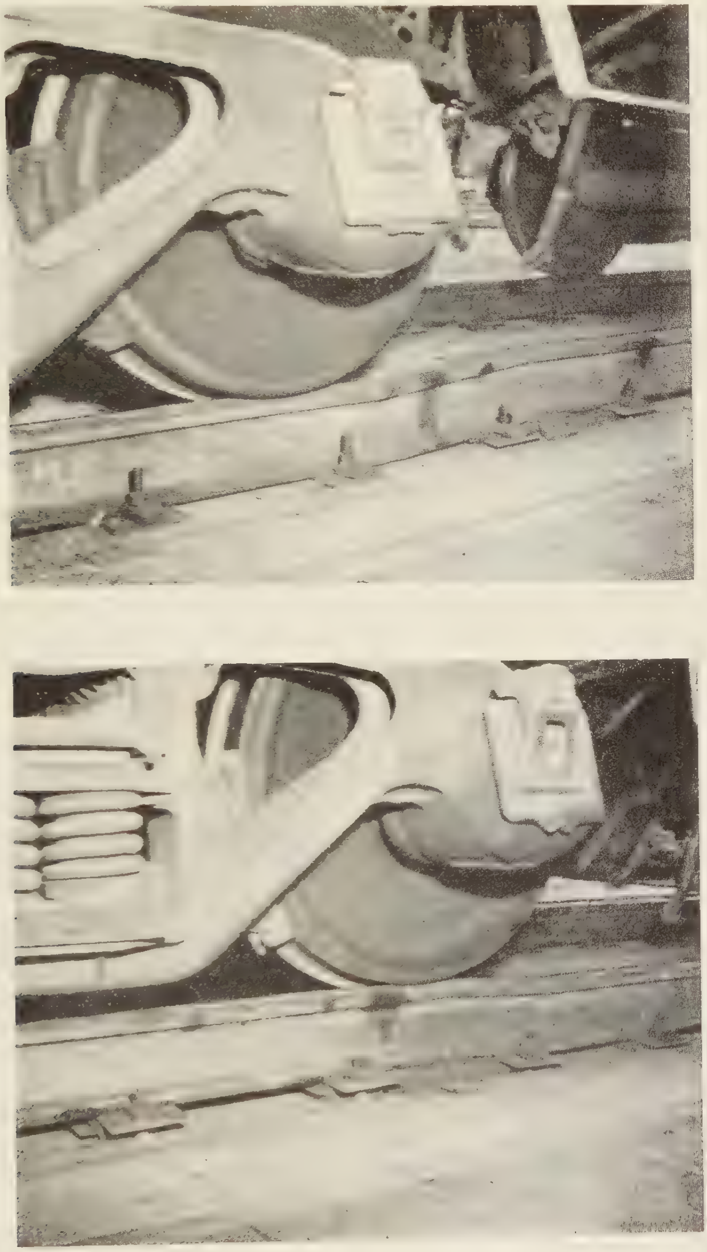
method, he pointed out, will not be sold. It will, instead, be installed by the company and then licensed to the railroad on a fixed-fee-per-car basis.

Said M. J. Buchman, executive vice-president of the firm : « Our studies have revealed that it costs the railroads an average of at least $ 10 for each of the approximately 22 million weighings they make each year ». The Railweight method, it was claimed, will do the job at a cost « of about $ 2 per car », and, in addition, can practically eliminate the usual delay incurred by weighing — especially in flat yards.

Installed nationwide, the Railweight method, according to its developers, could cut weighing time to the extent that the railroads would, in effect, gain 25 000 more cars. Mr. Levinson stated that weighing delays account for some 7.4 % of overall shipping time. He pointed out how the Railweight method could be installed in yard lead tracks, completely eliminating the need for separate weigh trackage, extra equipment, crews, etc. Damage loss reduction can also be achieved, the firm pointed out, by eliminating the usual recoupling impacts and, since all cars can be weighed in any train, overloads can be instantly detected and rectified.

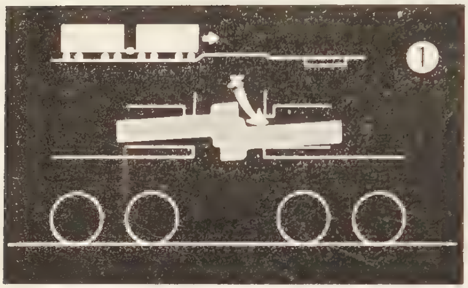
Twelve seconds per car—that's how fast cars can be weighed by the Railweight method.

Practically any type of recording equipment can be incorporated with the Railweight method, the developers point out. IBM card punching, tape printing or punching, or any method capable of fast revovery for in-motion weighing, can be used — depending upon the individual railroad's preference. Depending upon the circumstances, portions of existing scale facilities can possibly be adapted to the Railweight system.

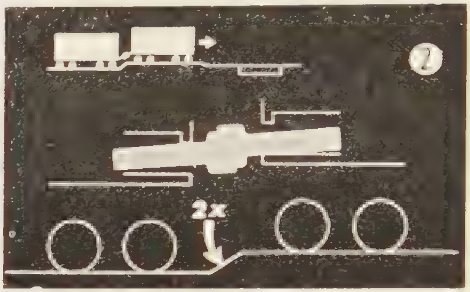


The key to the method lies in the Railweight « hump ».
Ascending lift (above) is double the descent (bottom).

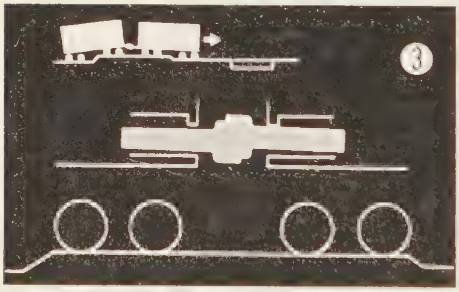
Elimination of weight transference between cars through the couplers ... is key to Railweight's new system of car weighing.



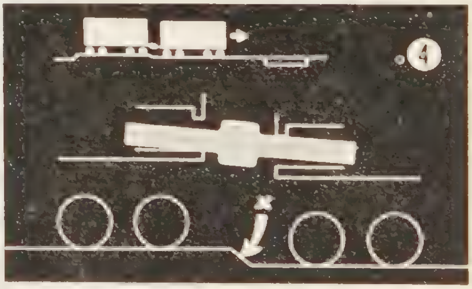
Coming into a yard off the main line, the positioning of the connecting couplers of any two adjacent cars will vary. Very seldom will they be accurately « in line ». Each coupler has a certain amount of vertical movement between the upper and lower faces of the striking casting in the car end sill. Let this amount of vertical coupler shank « play » be designated as « X ».



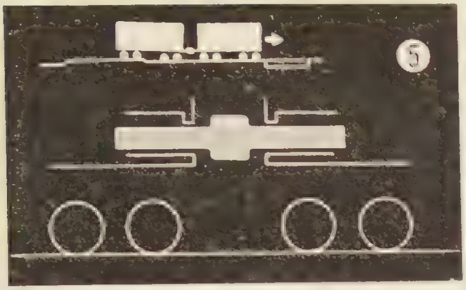
As the trailing truck of the lead car ascends the Railweight « hump », the trailing coupler of the lead car is deliberately misaligned with the lead coupler of the trailing car. Since the hump rise is equal to 2 X, the couplers are vertically displaced with respect to each other by the distance X



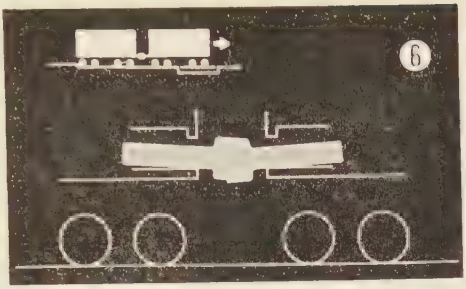
As the lead truck of the trailing car ascends the Railweight « hump », the deliberate coupler misalignment achieved in Step 2 is unchanged, still equal to X. The couplers, throughout this operation, are in constant tension as a result of the train movement.



As the trailing truck of the lead car descends from the Railweight « hump », the upper face of the lead car's striking casting contacts the coupler shank. Since the vertical descent from the hump is equal to the value « X » (the coupler « play »), the lead car's coupler is forced into alignment with the trailing car's coupler.



As the trailing car descends from the Railweight « hump », the coupler relation established in step 4 is maintained. The couplers connecting the two cars are now aligned and, since neither is in contact with the upper face of its striking casting, there can be no transfer of vertical load (car weight) from one coupler to the other.



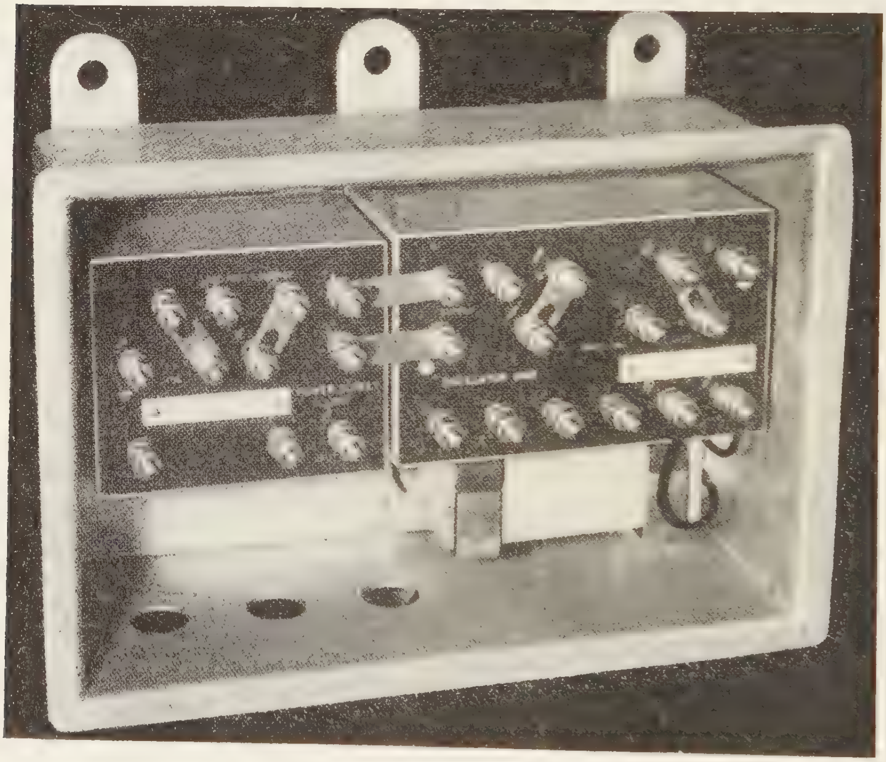
Even if the train should slow down and relieve the coupler tension, the alignment established by passing over the « hump » will remain and each coupler shank will rest on the lower face of its striking casting. Car weights are taken — one truck at a time — as the cars move over the one-truck capacity scale. The two truck weights thus obtained are added together to arrive at the total car weight.

[**656** .25 (42)]

Rail circuits without insulated joints.

London Transport uses short lengths of normally de-energised track circuit, known as " rail circuits, " for special signalling controls and has developed a 10-kc. type which requires no insulated joints.

(*The Railway Gazette*, November 22, 1957.)



Track feed set used with 10-kc. « rail circuits » in London Transport signalling installations.

What is known as the closed track, now so widely used to show whether a given section of track is, or is not, occupied by a train or vehicle, is so constructed that a current must flow continuously through out all parts of it to indicate that the portion of line concerned is unoccupied. The current is shunted away from the relay when a vehicle enters the circuit, producing the release of its armature and bring-

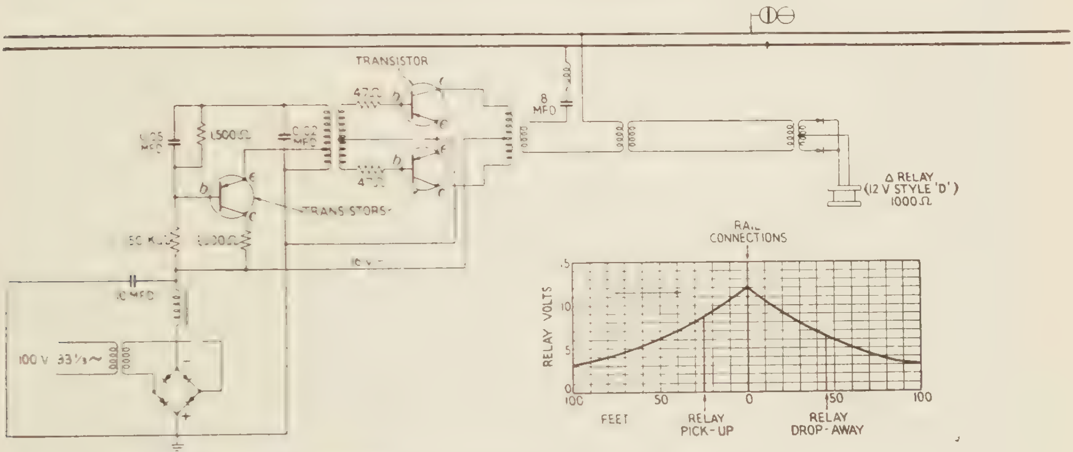
ing the desired signalling control into operation. Any defect in the circuit, such as a broken bond, relay winding or other electrical connection, or failure of the power supply, will have a like effect and produce an indication of track occupancy. In signalling language the circuit is arranged to fail on the safety side.

This is satisfactory as long as it is merely a question of being able to register track occupancy for the purpose of establishing a restricting control of some kind, such as holding a signal at danger or preventing points from being moved at the wrong time. It is desired sometimes, however, to release certain interlocking conditions when a train reaches a particular position and at no other time, and it is not satisfactory to rely merely on the working of a normal closed type track circuit, since this can become shunted accidentally for a moment, or suffer some failure producing the effect of a train having reached it.

« Delta » circuits.

It becomes necessary, therefore, to resort to an open — that is normally de-energised — circuit, in which the path for the current is completed by the presence of a vehicle, but as this cannot be used with safety to operate any actual locking control its length must be kept very short, so as not to interfere with the continuity of protection afforded by the ordinary track circuits of an installation. For some years London Transport has been using such short open track circuits, officially known as « rail circuits ». These are designated on diagrams by △, and in consequence are commonly referred to as « delta » circuits. It is necessary to put in additional insulated rail joints where such circuits are installed, giving an effective length of about 11 ft.

Such circuit will not, of course, produce the releasing effect if some part of it becomes disconnected, enabling it to be used with safety, in association with other controls, to release routes where, say, pre-selecting is in operation, or provide a delayed clearance for a signal or other like effect, as may be necessary. Insulated joints, however, cost money to install and maintain in order, while the civil engineer always is anxious to see as few of them as possible in his track. Attention has been directed therefore to obtaining the « rail circuit » effect with-



General electrical arrangement of jointless rail circuit and items essential to operation.

out having to use any additional joints and electronic equipment operating at relatively high frequency has been adapted to this requirement, as here described. (The frequency used, although a high one for track circuit work, would be regarded as low for radio or telecommunications.)

Jointless rail circuit.

The accompanying diagram shows the general electrical arrangement of the circuit and those items essential to its operation, while the photograph illustrates the lineside apparatus. By using full wave rectification from the ordinary signalling supply, which on L.T.E. lines has a frequency of 33 $^1/_3$, and transistors in conjunction with certain condensers, reactances and resistances, a 10 k/c current is created and imposed by transformation on a resonant circuit including the track rails.

By another transformer connection and rectifier the so-called △ relay becomes energised when a pair of wheels comes within about 25 ft. of the point where the track leads are connected to the rails and remains so until the wheels have passed about 45 ft. beyond it, enabling the « stick » control essential with the earlier form of rail circuit to be dispensed with.

At other times the impedance offered in the rails is much too large for any appreciable current to reach the relay. There is no interference from the normal 33 $^1/_3$ cycle track circuit current and the high frequency equipment cannot affect the ordinary track circuits in any manner. The rail circuit relay, which may be located up to 500 yd. from the track, is operated through equipment placed close to it and cannot be affected by extraneous D.C. or mains frequency A.C. at any part of the circuit.

As the effects of inductance obtained from a 10-k/c circuit are much higher than anything arising from ordinary signalling circuits the leads from the feed set to the rails have to be kept short and twisted together, all wiring kept as far as possible from telephone circuits and, when in relay rooms, carried out with paired wires, feed and return twisted together.

These new jointless rail circuits have been applied at many locations in connection with the new signalling operated from the re-equipped Cromwell Road signalbox at Earls Court, District Line, described in our issue of August 9 as indicated on the folding plate diagram of the layout then given. One of their principal uses is in connection with the release of route locking control on facing points, in association especially with preselection facilities, where a rail circuit must be actuated to prove the presence of a vehicle before such release can be given. It is then located 470 ft. ahead of the points to which it refers.

Another function is to release the backlock on a signal next in rear of the one standing at the facing points when a train has come to a stand at the latter, while yet another is to approach release a signal used to permit a train to come slowly up to another which is protecting a fouling route, so allowing the points in rear to be cleared and reversed as quickly as possible for another movement. The first signal in such cases itself locks the points in advance in whatever position they happen to be. The high frequency rail circuit may be said to be also a substitute for the much older treadle, or rail contact, used with interlocking block systems, requiring no adjustment for weight of rail and loads and functioning with certainty at any speed, however low. There are some 24 examples of it in service at the present time on L.T.E. lines.

CORRIGENDUM.

BULLETIN FOR FEBRUARY 1958.

Report on Question 3 (17th Session, Madrid 1958),

by Dr.-Ing. G. A. GAEBLER.

I. *Pages 158/14 and 159/15.* — Table 4*c* :

Swedish State Railways.

Type	*Instead of* :	YBo 6 and YBo 7	YBo 5 p & YBo 5 p
	Please read :	YBo 6 and YBo 7	YBo 5 p and YFo 5 p
Normal composition	*Instead of* :	M.U. + T. + C.T.	M.U. + T. + C.T.
of set (1)	*Please read* :	(5)	(5)

Number of seats 1st/2nd class :

c) Control trailer.	*Instead of* (7th col.) :	—/32 — 50
	Please read :	—/32 — 50 (3)
Luggage compartment	*Instead of* (7th col.) :	36 in T. 24 in M.U. up to 12.5 in C.T.
	Please read :	36 in T. 24 in M.U. up to 12.5 in C.T. (3)

Note (5) *must be replaced by the following wording :*

(5) These are no standard sets. The composition of motor units, control trailers and trailers into sets varies greatly, up to 10 units being used to make up sets, in which it is usual that the number of motor units exceeds the number of ordinary and control trailers.

II. *Pages 160/16 and 161/17.* — Table 4*c (continued)* :

Swedish State Railways.

Average annual cost of maintenance and repair in per cent of capital cost :

a) Motor unit	*Instead of* (6th col.) :	240 (5);	*please read* : 20
b) Trailer	*Instead of* (6th col.) :	100 (5);	*please read* : 8
c) Control trailer	*Instead of* (6th col.) :	— ;	*please read* : 8

Note (5) *on page 160/16 must therefore be cancelled.*

III. *Page 179/35* (right column), 21st and 22nd lines, there is :
« Considering that the acceleration at the *lower* speed range... »

Please read :
« Considering that the acceleration at the *higher* speed range... »

IV. *Page 182/38 :*

1st column (11th line from the top) :

Instead of : All Administrations with the exception of that of the Swedish State Railways state....

Please read : All Administrations state...

Page 185/41. — Table 6 :

Sweden. — In the column : Actual ratios (*) :

There is : 4.4 to 4.7.

Instead of : 4.4 to 4.7 (**),

and please add the following footnote : (**). Cf. footnote (5) of Table 4*c*.

V. *Page 186/42.* — Table 7 :

	3rd col. : Basic unit consists of (*).	*4th col. : Built-in Power/weight...*
Sweden. — Instead of :	M.U. + T. + C.T. M.U. + T. + C.T.	4.44 4.7
Please read :	(**)	Please cancel these figures.

At the bottom of this page, please add the following Note (**) :
(**) Cf. footnote (5) on Table 4*c*.

VI. *Page 201/57 :*

Fig. 13. — The legend must be rectified as follows : « Drawing of the Swedish Diesel railcar — Type YBo 6 ».

CORRIGENDUM.

BULLETIN FOR APRIL 1958.

Report on Question 3 (17th Session, Madrid 1958),
by A. S. CANAVEZES Jr.

Pages 501/61 (Table 1) and 515/75 (Table 3):

The denomination : « French West Africa and Togoland Colonial Railways » *must be replaced as follows :*

« Régie des Chemins de fer de l'A.O.F. et Chemin de fer du Togo. »

CORRIGENDUM.

BULLETIN FOR MAY 1958.

Report on Question 7 (17th Session, Madrid, 1958),
by B. H. de FONTGALLAND.

Page 697/15 (left column):

The denomination « Chemins de fer Coloniaux de l'Afrique Occidentale Française et Togo » *must be replaced by:*

« Régie des Chemins de fer de l'A.O.F. et Chemin de fer du Togo. »

CORRIGENDUM.

BULLETIN FOR FEBRUARY 1958.

Report on Question 6 (17th Session, Madrid 1958),
by R. CARLIER.

On page 105/21 (right column), 4th paragraph :

There is : « The U.S.S.R. Railway Administration reports that it puts into service at the peak hours for a short period carriages with no seats. »

Please read : « The U.S.S.R. Railway Administration reports that on suburban traffic, carriages with 108 seats are used. Multiple-unit trains with 9 carriages are in service both during peak hours and during periods when the flows of passengers decrease. There are identical hard seats in all coaches on electrified sections. During peak hours, passengers can travel without having seats for journeys within 10 to 15 km. »

MONTHLY BIBLIOGRAPHY OF RAILWAYS (1)

PUBLISHED UNDER THE SUPERVISION OF

P. GHILAIN,

General Secretary of the Permanent Commission of the International Railway Congress Association.

(JULY 1958)

[**016. 385** (02]

I. — BOOKS.

In French.

1957 62 (01

AROUTIOUNIAN (N.Kh.).

Application de la théorie du fluage. Traduit du russe par P. MROZOWICZ.

Paris, Eyrolles, éditeur. In-8°, VIII-320 pages avec figures. (Prix : 4 500 fr.fr.)

1958 624

KANI (G.).

Le calcul des portiques étagés multiples. Traduit de l'allemand par W. SADOWSKY.

Paris, Dunod, éditeur. Un volume (14 × 22 cm) de XII + 121 pages avec 34 figures et 6 tableaux. (Prix : broché, 1 180 fr. fr.)

1958 691

Matériaux de construction. Verre, fibres de verre et matériaux de synthèse.

Paris, Eyrolles, éditeur. Un volume (22 × 28 cm) de 342 pages, avec 437 figures et 31 tableaux. (Prix : 4 000 fr. fr.)

1958 691

PADUART (A.).

Manuel de calcul de béton armé. Compression, Traction, Flexion.

Bruxelles, édité par le Centre d'Information de l'Industrie Cimentière Belge, 127, avenue Adolphe Buyl. 60 pages, 26 figures, 6 tableaux et 7 abaques hors-texte. (Prix : 60 fr.)

In German.

1958 621 .3 (02

75 Jahre Elektrotechnischer Verein Österreichs.

Festnummer : **Elektrotechnik und Maschinenbau,** Heft 9, 1. Mai 1958.

Wien I, Springer-Verlag, Mölkerbastei 5. Verschiedene Aufsätze von Fachleuten der Elektrotechnik. 162 Seiten (21 × 30 cm) mit zahlreichen Abbildungen

1957 721 .9

Stahlbau. Ein Handbuch für Studium und Praxis.

Köln, Stahlbau-Verlag. Ein Band (17 × 24 cm) von 708 Seiten mit 1783 Abbildungen. (Preis: geb. DM 48.—.)

In English.

1958 656

Annual Report 1956-57. Railway Testing and Research Centre. — Railway Board, India.

Lucknow : Published by Director Research, Railway Board, India. (No price stated)

1958 385 (09

DAY (J.R.) and WILSON (B.G.).

Unusual Railways.

London : Frederick Muller Limited. (Price : 21 s.)

1958 385 (02

Engineering Materials Handbook.

Edited by Charles L. MANTELL.

London : McGraw-Hill Publishing Company, Ltd., 95, Farringdon Street, E.C. 4. (Price : 167 s.)

1958 621 .131 .3

HOLCROFT (H.).

An outline of great western locomotive practice, 1837-1947.

Hampton Court, Surrey : The Locomotive Publishing Company, Ltd., Craven House. (Price : 25 s.)

1958 656 .27

KIDNER (R.W.).

Standard gauge light railways.

Light Railway Handbooks, No. 1. Fourth edition. One brochure (7 1/4 × 4 3/4 in.) of 56 pages, illustrated.

Lingfield, Surrey : The Oakwood Press, Bucklands, Tandridge Lane. Paper covers. (Price : 6 s.)

1958 656

VAN METRE (T.W. and R.G.).

Trains, tracks and travel.

New York : Simmons-Boardman Publishing Corporation (obtainable in U.K. from Ian Allan Ltd., London). (Price : 25 s.)

(1) The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress conjointly with the Office Bibliographique International, of Brussels. (See « Bibliographical Decimal Classification as applied to Railway Sience », by L. WEISSENBRUCH in the number for November 1897, of the *Bulletin of the International Railway Congress*, p. 1509)

[016. 385 (05]

II. — PERIODICALS.

In French.

Acier - Stahl - Steel. (Bruxelles.)

1958 **624** .2

Acier - Stahl - Steel, mai, p. 223.

BAZILE-BENOIT (A.). — **Déformations verticales des poutres fléchies d'inertie constante.** (500 mots, tableaux & fig.)

Annales des Travaux Publics de Belgique. (Bruxelles.)

1957 **691**

Annales des Travaux Publics de Belgique, juin, p. 71.

MOENAERT (P.) et PADUART (A.). — Les **travaux du Comité Européen du Béton.** Résultats de la Session tenue à Rome du 23 au 27 avril 1957. **(Recherche d'une méthode de calcul à la rupture).** (6 000 mots & fig.)

Bulletin de l'Association Suisse des Electriciens. (Zürich.)

1958 **621** .31

Bull. de l'Assoc. Suisse des Electriciens, n° 9, 26 avril, p. 408.

LOCHER (K.). — Verfahren zur **Messung der Flexibilität von Litzen, Kabeln und Leitungsschnüren.** (1 500 mots, tableaux & fig.)

1958 **621** .31

Bull. de l'Assoc. Suisse des Electriciens, n° 10, 10 mai, p. 448.

SCHÄR (F.). — Aus der Praxis der **Leistungsfrequenzregelung.** (4 000 mots & fig.)

Bulletin des C.F.F. (Berne.)

1958 **385** .113 (494)

Bulletin des C.F.F., mai, p. 70.

THOMANN (F.). — Le **compte de résultat de 1957** des Chemins de fer fédéraux. (1 000 mots.)

1958 **621** .33 (44)

Bulletin des C.F.F., mai, p. 74.

DESPONDS (C.). — L'**électrification** des lignes Dôle-Vallorbe et Frasne-Pontarlier. (1 500 mots & fig.)

1958 **385** .57

Bulletin des C.F.F., mai, p. 77.

STRÄSSLE (Th.). — **Aptitude au service des chemins de fer.** (1 200 mots.)

1958 **625** .23 (494)

Bulletin des C.F.F., mai, p. 79.

Nouvelles voitures des C.F.F. (600 mots & fig.)

Bulletin de Documentation S.C.E.T.A. (Paris.)

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Bulletin de Documentation S.C.E.T.A., mai, p.1.

GUIBERT (R.). — Le **transport par wagons de véhicules routiers utilitaires.** (3 400 mots & fig.)

1958 **656** (73)

Bulletin de Documentation S.C.E.T.A., mai, p. 8.

Les problèmes actuels de transports aux U.S.A. - II. (3 700 mots.)

Bulletin Sécheron. (Genève.)

1958 **621** .31

Bulletin Sécheron, n° 27 F., p. 8.

ROSSIER (Cl.). — Quelques particularités des **transformateurs à trois enroulements.** (2 500 mots & fig.)

1958 **621** .31

Bulletin Sécheron, n° 27 F., p. 23.

KRATZER (R.). — L'**impédance homopolaire des transformateurs.** (2 600 mots & fig.)

Bulletin de la Société Française des Electriciens (Paris.)

1958 **669** .1

Bulletin de la Soc. Franç. des Electriciens, janvier, p. 52.

POMEY (J.). — Recherche sur le **traitement superficiel des aciers par induction électromagnétique de haute fréquence.** (10 000 mots & fig.)

1958 **621** .33

Bulletin de la Soc. Franç. des Electriciens, février, p. 85.

GARREAU (M.). — La **collaboration des constructeurs et du client dans les récents progrès de la traction électrique.** (3 500 mots.)

1958 **621** .33

Bulletin de la Soc. Franç. des Electriciens, février, p. 107.

TROGNEUX (M.). — **Effets des lignes de traction monophasées à 50 Hz sur les installations riveraines.** (5 000 mots & fig.)

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M. Weissenbruch & Co., Ltd., Printer to the King, 49, rue du Poinçon, Bruxelles.